Division of Agricultural Sciences

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SOME CHARACTERISTICS OF DEMAND FOR FROZEN VEGETABLES

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FOREWORD

This is one of a series of reports dealing with the competitive position of the Western Region in marketing frozen fruits and vegetables. The present study focuses on the behavior of frozen vegetable consumption and the factors associated with it. Since continuous series on regional consumption of frozen vegetables are not available, the analysis is developed primarily in terms of national aggregates. Such regional data as are available are included, however, and this should permit adaptation of the demand estimates in further regional analysis.

This study is part of work being carried on by the California Agricultural Experiment Station under Western Regional Marketing Research Project Number WM-17, in cooperation with the Experiment Stations of Oregon, Washington, and Hawaii, and with the Economic Research Service of the United States Department of Agriculture.

Much credit is due to G. A. King and R. H. Reed for many helpful comments during preparation of the report.

Previous Publications in This Series by the Giannini Foundation, University of California

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SOME CHARACTERISTICS OF DEMAND FOR FROZEN VEGETABLES

by

Ben C. French[1]

INTRODUCTION

The frozen vegetable industry, which started modestly in the period just prior to World War II, has grown rapidly in the years since the war, both nationally and in California. Because of the newness of the industry and the scarcity of needed data, few quantitative estimates of demand relationships have been developed for these commodities. Such estimates may be particularly useful as guides to processors and others in formulating marketing policies and programs and they are a necessary ingredient in models of interregional competition and economic projections of importance to the industry.

This report discusses the important dimensions of demand for frozen vegetables and develops estimates of relationships among prices, income, consumption, and other demand factors. The first part of the report provides background materials needed to understand the relationships underlying the general structure of demand and the analysis that follows. Included are trends in consumption of frozen and competing fresh and canned vegetables, regional and commodity variations, and price changes and price margins.

The second part presents the results of statistical analyses of cross-section data concerning household consumption, income, and other family characteristics and time series of price and consumption data in which cross-section results are utilized as constraints in the analysis. Because of serious intercorrelation problems, the study is developed initially for frozen vegetables in the aggregate. A final section then suggests a method of adapting the aggregate demand function to individual vegetables.

HISTORICAL PERSPECTIVE

Frozen Vegetables in the Total Market

The growth of total per capita consumption of frozen vegetables is illustrated in Figure 1 in relation to changed in consumption in fresh and canned forms. Most of the significant growth in frozen consumption has occurred in the years since

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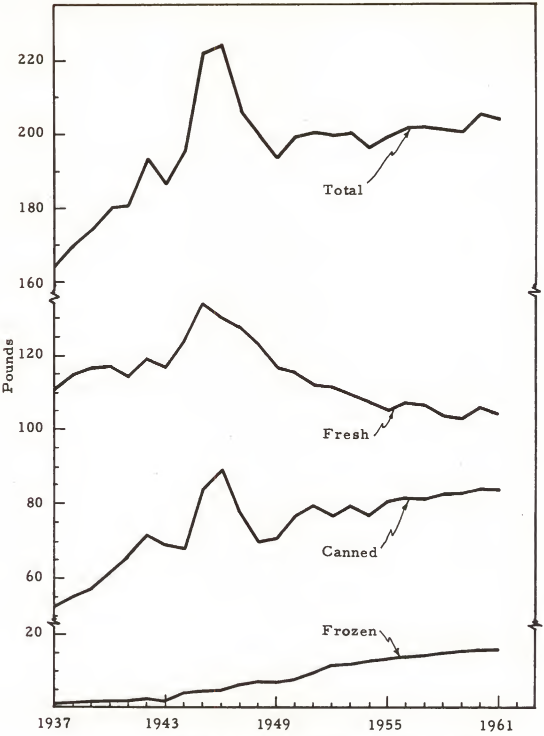

FIGURE 1. Changes In United States Per Capita Vegetable Consumption, 1937-1961, Fresh Equivalent.

World War II -- from about 6 pounds per capita in 1946 to 16 pounds in 1961. Following a sharp decline from the wartime peak, per capita consumption of canned vegetables has also trended upward. These increases in processed consumption have been largely at the expense of fresh vegetables, with total consumption showing only a slight upward trend.

In percentage terms, consumption in fresh form decreased from about 59 percent of the total in 1947 to about 51 percent in 1961; canned consumption increased from about 38 to 41 percent and frozen consumption from 3 to about 8 percent of the total. Viewed in these total terms, frozen vegetables still represent only a minor part of all vegetable consumption. However, about 35 percent of this total consists of tomatoes and cabbage which are not frozen. Frozen vegetables assume much greater significance if we look at individual commodities.

Figure 2 shows how the fresh, canned and frozen components of consumption have varied for each of nine vegetables of major importance to the freezing industry.1/ For all commodities except corn the increase in frozen per capita consumption has been associated with a decrease in fresh consumption. The association with canned consumption has been more varied. In the postwar years the per capita consumption of canned peas and spinach has declined moderately while the canned consumption of other commodities has either increased or at least held steady. Changes in the relative importance of these components are shown in Table 1. In 1961, for example, the frozen component accounted for 19 percent of all asparagus consumption, 63 percent of Lima bean consumption, 66 percent of broccoli consumption, 78 percent of Brussels sprouts consumption, and so on.

Components of Frozen Vegetable Consumption

The form of Figure 2 and the fresh weight values make comparisons among individual frozen vegetables somewhat awkward and misleading. Figure 3 illustrates consumption variations among the several frozen vegetables, expressed on a frozen weight basis. Variations in relative shares of each vegetable in total consumption are summarized in Table 2. Peas have always been by far the leading frozen vegetable product, with consumption more than double that of any other commodity. Lima beans, second in consumption for many years, now appear to be challenged for this position by snap beans and corn. Per capita consumption of all frozen vegetables has continued to increase, although for some commodities, particularly

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1/ The processed components are slightly understated for some commodities as the figures exclude quantities consumed in commercially produced soups and baby foods and in vegetable mixtures such as peas and carrots and succotash. The data are given in Appendix Table A2.

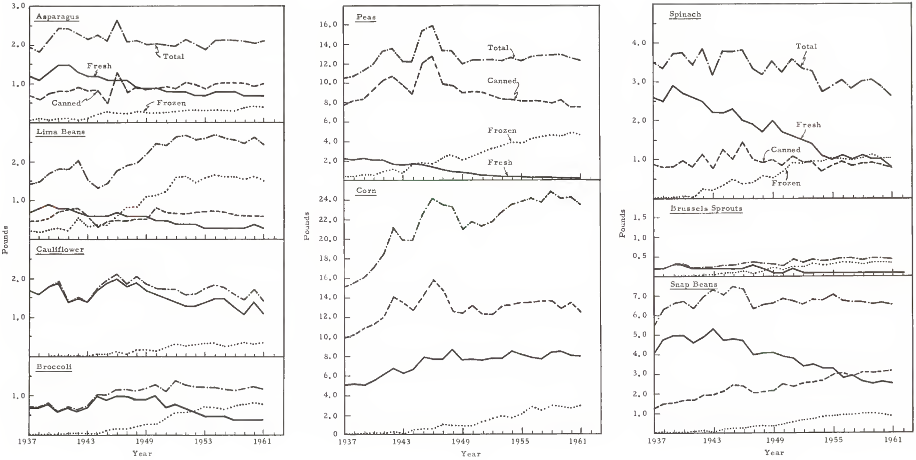

FIGURE 2. Civilian Per Capita Consumption of Selected Commercially Produced Fresh and Processed Vegetables, United States, Calendar Years 1937-61, Fresh Equivalent Basis.

TABLE 1

Percent of Consumption in Fresh, Canned and Frozen Form for Nine Vegetables, 1937-61

Commodity	1937-40	1941-44	1945-48	1949-52	1953-56	1957-60	1961
	percent						
Asparagus							
Fresh	61.2	56.8	48.8	42.4	36.6	35.6	33.3
Canned	34.8	37.5	39.0	44.4	47.6	47.5	47.6
Frozen	4.0	5.7	12.2	13.2	15.8	16.9	19.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Lima beans							
Fresh	50.0	40.9	35.7	20.7	13.3	12.6	12.4
Canned	34.6	36.7	28.0	27.8	26.7	25.1	24.9
Frozen	15.4	22.4	36.3	51.5	60.0	62.3	62.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Snap beans							
Fresh	75.0	70.5	63.4	56.7	47.1	39.8	38.3
Canned	24.1	27.7	32.2	35.6	40.9	45.6	48.5
Frozen	.9	1.8	4.4	7.7	12.0	14.6	13.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Broccoli							
Fresh	97.6	94.4	84.9	68.6	46.4	35.9	33.6
Frozen	2.4	5.6	15.1	31.4	53.6	64.1	66.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Brussels sprouts							
Fresh	98.4	81.6	67.8	36.0	23.8	22.5	22.2
Frozen	1.6	18.4	32.2	64.0	76.2	77.5	77.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Cauliflower							
Fresh	99.8	98.7	94.6	87.2	80.9	80.0	74.8
Frozen	.2	1.3	5.4	12.8	19.1	20.0	25.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Corn							
Fresh	32.9	32.8	34.7	35.9	34.4	33.7	34.0
Canned	66.2	66.0	61.9	58.6	56.6	55.1	53.6
Frozen	.9	1.2	3.4	5.5	9.0	11.2	12.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Peas							
Fresh	19.9	13.8	8.6	5.1	3.0	1.9	1.6
Canned	75.6	77.6	76.8	73.2	66.0	61.8	60.8
Frozen	4.5	8.6	14.6	21.7	31.0	36.3	37.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Spinach							
Fresh	74.6	67.1	56.1	49.8	38.6	35.1	30.5
Canned	24.3	27.6	30.9	28.1	28.2	29.8	29.8
Frozen	1.1	5.3	13.0	22.1	33.2	35.1	39.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Computed from data in Appendix Table A2.

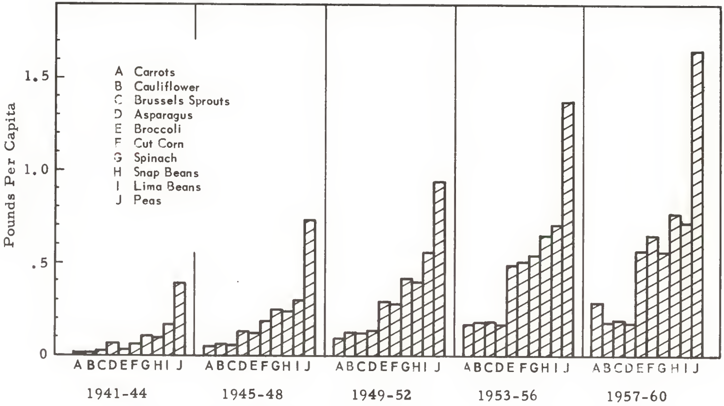

FIGURE 3. United States Civilian Per Capita Consumption Of Major Frozen Vegetables, 1941 to 1960.

TABLE 2

Individual Commodity Shares of United States
Frozen Vegetable Consumption, 1941-1961 a/

Period	Peas	Snap beans	Lima beans	Cut corn	Spinach	Broc-coli	Carrots	Brussels sprouts	Cauli-flower	Aspara-gus	Other b/	Total
	percentage of total consumption											
1941-44	39.4	9.0	16.9	5.4	9.8	3.3	1.5	2.3	0.8	6.5	5.1	100.0
1945-48	32.0	10.1	12.5	7.9	10.7	5.0	2.7	2.5	2.5	5.7	8.4	100.0
1949-52	26.0	10.5	15.1	7.4	11.0	7.6	3.5	3.2	3.3	3.6	8.8	100.0
1953-56	25.2	11.5	12.7	9.1	9.6	8.8	3.7	3.2	3.2	2.9	10.1	100.0
1957-60	25.6	11.5	10.7	9.8	8.4	8.5	5.4	2.8	2.7	2.6	12.0	100.0
1961	24.4	9.6	9.6	9.9	8.1	8.4	5.7	2.7	2.8	2.8	16.0	100.0

a/ Total excludes potato products.

b/ Other includes pumpkin and squash, succotash, rhubarb and various greens.

Source: Computed from Appendix Table A1.

asparagus, cauliflower, and Lima beans, the rate of increase has been small in recent years.

In 1961 about half of all frozen vegetables were packed in retail size containers (under one pound). The percentage has varied somewhat among commodities (Table 3). In recent years an increasing proportion of the pack has been in institutional size containers. With lower handling costs, per pound prices for institutional packs typically are less than for retail sizes.

Regional Variations

Data on regional per capita consumption of frozen vegetables are not available on a continuing basis. The primary source of such information is a study by Reese, which relies on data obtained in two surveys -- the 1955 Household Food Consumption Survey (USDA) and information purchased from the Market Research Corporation of America, obtained from a National Consumer Panel.1/ Estimates of 1955 regional per capita consumption of seven frozen vegetables are given in Table 4. The values differ slightly from those given by Reese in that they have been adjusted proportionately so that the weighted average per capita consumption is the same as the 1955 United States average for these vegetables, as published in the regular USDA series.2/ Table 5 expresses the Table 4 values as percentages of United States average per capita consumption for each vegetable.

These estimates suggest a much higher than average rate of consumption in the Northeast and Western states and very low consumption levels in the West South Central region. The variations among regions are broadly consistent with the findings of a 1959 frozen food sales survey conducted by Harold L. Franklin for Quick Frozen Foods.3/ The survey results are summarized in Table 6. The per capita dollar sales are also expressed as percentages of the United States average and compared with similar figures based on the per capita quantities, including fruits, given in the Reese Report.

Prices and Margins

Annual average f.o.b. processing plant prices for the major frozen vegetables are given in Table 7. The prices were computed from monthly trade journal price

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1/ Reese, Robert B., Family Purchases of Selected Frozen Fruits and Vegetables, USDA, Agricultural Marketing Service, Research Report No. 317, 1959.

2/ See Appendix Table A3.

3/ Quick Frozen Foods, E. W. Williams Publications, Inc., N. Y., March 1961. Surveys covering 100 metropolitan markets were also made for 1959 and 1960. The metropolitan market data were not summarized regionally.

TABLE 3

Percent of United States Frozen Vegetable Pack Sold in
Retail Sizes, 1947 to 1961 a/

Year	Asparagus	Lima beans	Snap beans	Broccoli	Brussels sprouts	Cauliflower	Cut corn	Peas	Spinach	All vegetables
	Percent of total pack									
1947	72	57	54	68	77	70	32	57	72	58
1948	70	61	61	71	76	70	38	60	76	64
1949	73	53	64	74	73	71	36	57	78	65
1950	74	63	66	74	78	71	42	59	78	66
1951	60	66	69	80	71	73	38	61	78	68
1952	68	65	68	76	74	61	39	57	79	66
1953	75	60	64	81	77	76	42	54	73	65
1954	66	62	63	78	65	64	41	58	70	64
1955	67	65	64	72	78	64	46	58	75	65
1956	63	64	64	78	73	65	39	53	73	61
1957	66	58	64	79	73	73	40	46	70	58
1958	61	60	63	76	77	68	43	47	74	57
1959	60	58	59	75	71	65	41	48	71	55
1960	52	58	59	76	72	70	34	39	72	49
1961	47	46	60	76	72	72	39	40	73	49

a/ Packages weighing one pound or less are classed as retail sizes.

Source: Computed from pack data published by the National Association of Frozen Food Packers.

TABLE 4

Regional Variations in Civilian Per Capita Consumption of Selected Frozen Vegetables, 1955

Vegetable	Region[a/]						
	North-east	East North Central	West North Central	South	West South Central	West	United States
	pounds						
Green peas	2.12	1.06	.99	.69	.43	2.38	1.34
Lima beans	.86	.57	.28	1.04	.37	.69	.72
Snap beans	1.17	.57	.28	.32	.20	1.00	.66
Spinach	1.01	.48	.23	.38	.36	.58	.57
Broccoli	.83	.41	.41	.45	.33	.58	.54
Cut corn	.54	.49	.68	.29	.44	.85	.51
Asparagus	.32	.16	.08	.06	.03	.18	.16
Total - seven vegetables	6.89	3.70	2.83	3.30	2.15	6.14	4.50

a/ States included in each region are as follows: Northeast: Maine, New Hampshire, Vermont, Massachusetts, Connecticut, New York, Pennsylvania, New Jersey, Maryland, Delaware, District of Columbia; East North Central: Ohio, Indiana, Michigan, Illinois, Wisconsin; West North Central: Minnesota, North Dakota, South Dakota, Nebraska, Iowa, Missouri; Southeast: Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Kentucky, Tennessee, Alabama, Mississippi; West South Central: Arkansas, Louisiana, Oklahoma, Texas; West: California, Washington, Idaho, Montana, Wyoming, Utah, Colorado, Nevada, Arizona, New Mexico.

Source: Reese, Robert B., Family Purchases of Selected Frozen Fruits and Vegetables, USDA, Agricultural Marketing Service, Research Report No. 317, 1959, p. 83. The consumption estimates given in the Reese report have been adjusted proportionately upward here so as to give a weighted average per capita consumption the same as the United States average for 1955 as published in the regular USDA per capita consumption series. (see Appendix Table A1.)

TABLE 5

Relative Variations in Regional Per Capita Consumption of Selected Frozen Vegetables, 1955

Vegetable	Region						
	North-east	East North Central	West North Central	South	West South Central	West	United States
	percent of United States average						
Green peas	158	79	74	51	32	177	100
Lima beans	119	78	39	144	52	95	100
Snap beans	177	87	42	48	31	152	100
Spinach	177	84	41	66	63	102	100
Broccoli	154	76	76	84	62	108	100
Cut corn	107	97	133	57	87	167	100
Asparagus	200	100	50	40	20	110	100
Total - seven vegetables	153	82	63	73	48	137	100

Source: Computed from Table 4.

TABLE 6

Regional Variations in 1959 Food Store Frozen Fruit and Vegetable Per Capita Dollar Sales Compared With 1955 Estimates of Average Pounds Purchased Per Family Member

	New England	Middle Atlantic	East North Central	West North Central	South Atlantic	East South Central	West South Central	Mountain	Pacific	United States
	per capita dollar sales									
Quick Frozen Foods Survey	2.96	2.75	2.39	1.50	1.23	.75	1.46	1.41	2.97	2.08
	percent of United States average									
Quick Frozen Foods Survey	142	132	115	72	59	36	70	68	143	100
	Northeast				South			West		
Reese Report[a]	148		91	76	72		50	124		100

a/ Includes both frozen fruits and vegetables.

Source: Quick Frozen Foods, E. W. Williams Publications Inc., N. Y., March 1961, p. 163-194. Reese, Robert B., Family Purchases of Selected Frozen Fruits and Vegetables, USDA, Agricultural Marketing Service, Research Report No. 317, 1959. Percentages computed from Table 38, p. 83 of the report.

TABLE 7

F.O.B. Processing Plant Prices for Frozen Vegetables: United States Average for Principal Grade A Retail Sizes, 1947-1961 a/

Year	Asparagus	Lima beans b/	Snap beans	Broccoli	Brussels sprouts c/	Cauliflower	Cut corn	Peas	Spinach	Average for nine vegetables d/
	cents per pound									
1947	32.6	30.6	22.3	23.9	31.0	25.0	20.0	20.4	15.4	24.0
1948	36.8	30.2	24.6	25.5	32.1	26.3	20.6	22.1	16.0	24.3
1949	41.1	29.3	25.4	27.0	32.2	26.6	21.2	20.8	15.8	24.7
1950	44.3	25.0	24.0	24.6	31.5	24.9	22.2	20.3	14.7	22.8
1951	45.6	25.3	25.5	25.7	30.4	26.6	22.1	20.2	15.1	23.1
1952	44.9	26.0	24.7	25.9	25.9	25.7	22.2	20.5	15.5	23.4
1953	44.5	28.7	25.6	25.6	28.9	24.6	23.4	19.5	14.3	23.7
1954	43.5	27.3	24.3	22.5	27.8	22.0	19.8	18.2	13.8	21.9
1955	47.8	24.4	22.2	23.1	23.6	24.7	17.5	20.6	13.9	21.7
1956	45.2	22.6	21.2	23.2	24.9	24.5	19.9	20.4	12.8	21.4
1957	42.8	23.1	21.3	21.3	24.3	21.5	18.0	16.7	12.2	19.6
1958	39.7	23.1	22.7	21.8	24.3	21.8	17.7	17.2	13.9	20.0
1959	40.6	22.7	22.1	20.3	27.7	21.4	22.0	18.5	13.3	20.8
1960	44.0	23.9	22.3	21.4	28.4	21.3	21.6	20.2	12.1	21.7
1961	46.2	22.9	21.3	20.0	29.1	20.9	19.4	19.7	11.8	20.8

a/ Averages for principal producing regions -- East and South, Northwest, California -- weighted by regional pack.

b/ Fordhook variety.

c/ California price.

d/ Weighted by annual per capita consumption.

Source: Computed from prices quoted in monthly issues of Quick Frozen Foods.

quotations and do not necessarily reflect discounts, deals, and other variations that may be involved in actual transactions. In some cases the monthly data were incomplete and required some interpolation. The figures thus are not as precise as we might like to have, but they have been carefully computed and are the best available. They appear to give reasonable indications of movements and general levels of prices.

Prices of most frozen vegetables have declined gradually since the late 1940s. In a following section it is argued that much of this decline can be accounted for by increases in supply.

An indication of the variation in prices at different levels in the marketing channels -- farm, wholesale, and retail -- is given in Table 8. It must be stressed that the "margins" shown -- the differences, ratios, and percentages -- are only <u>indications</u> and not the actual margins. In some cases, as stated in the table, available farm price data include fresh market sales or sales for canning, as well as freezing. Retail prices, although typical, are for a single area -- Washington, D.C.[1/] Official factors for converting from farm weight to frozen weight are also subject to some error and a specific unit of commodity may be purchased from producers in one period and sold at retail in another. However, even with allowance for these factors, it seems likely that the average magnitudes of the actual margins may be roughly of the order given in Table 8.

The figures in Table 8 are presented primarily for background and few conclusions of significance can be drawn without additional information. It is interesting to note, however, the fairly high degree of consistency among vegetables in the ratio of retail to f.o.b. plant price and the f.o.b. price as a percent of retail. The greater variation in the ratios to farm price may be due, in part, to unknown errors in the factors used to convert from a farm to a frozen weight basis.

ANALYSIS OF DEMAND RELATIONSHIPS

Structure of Demand

The production and marketing structure for frozen vegetables involves several kinds of demand relationships -- demand at various levels in the channels of distribution, at different geographic locations and for products of varying type, size,

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1/ For a comparison of retail prices in two other cities with the Washington, D.C. prices, see Appendix Table A4.

Frozen Vegetable Price Comparisons: Farm, F.O.B. Processing Plant and Retail, Frozen Weight Basis, 1957-58 to 1960-61 Average a/

	Asparagus	Lima beans	Snap beans	Broccoli	Brussels sprouts	Cauliflower	Corn	Peas	Spinach
	cents per pound								
Average price									
Farm	20.0	8.1	7.8	10.3	10.1	11.5	4.6	5.0	3.5
F.O.B. (i) b/	37.4	--	18.8	18.4	22.1	18.1	17.2	15.9	10.8
F.O.B. (r) c/	41.6	23.5	22.1	20.6	27.1	21.5	19.6	18.3	12.7
Retail	76.9	42.2	41.1	42.6	54.5	43.0	34.0	31.9	29.5
Price differences									
F.O.B. (i) less farm	17.4	--	11.0	8.1	12.1	6.6	12.6	10.9	7.3
F.O.B. (r) less farm	21.6	15.4	14.3	10.3	17.0	10.0	15.0	13.3	9.2
Retail less farm	56.9	34.1	33.3	32.3	44.4	31.5	29.4	26.9	26.0
Retail less F.O.B. (r)	35.3	18.7	19.0	21.9	27.4	21.5	14.4	13.6	16.8
Price ratios									
F.O.B. (i) ÷ farm	1.9	--	2.4	1.8	2.2	1.6	3.8	3.2	3.1
F.O.B. (r) ÷ farm	2.1	2.9	2.8	2.0	2.7	1.9	4.3	3.7	3.7
Retail ÷ farm	3.8	5.2	5.3	4.1	5.4	3.7	7.5	6.4	8.5
Retail ÷ F.O.B. (r)	1.9	1.8	1.9	2.1	2.0	2.0	1.7	1.7	2.3
	percentage								
Percent of retail price									
Farm	26.0	19.2	19.0	24.2	18.5	26.7	13.5	15.7	11.9
F.O.B. (r)	54.1	55.7	53.8	48.4	49.7	50.0	57.6	57.4	43.1
Retail	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

a/ Prices are expressed on a crop year basis to conform to the method of reporting farm prices. Farm and f.o.b. plant prices are approximate United States averages with the exception of the f.o.b. prices of asparagus and broccoli. The latter are for the western region only. Retail prices are for the Washington, D.C. area. Retail and f.o.b. prices are quoted on the principal size, grade A product. Farm prices of asparagus and spinach include vegetables for both canning and freezing. Farm prices of broccoli, Brussels sprouts and cauliflower include both fresh market and frozen vegetables. Farm prices are converted to a frozen weight basis using USDA conversion factors (Conversion Factors and Weights and Measures for Agricultural Commodities and their Products, USDA, PMA, May 1952).

b/ Institutional sizes, one pound and larger.

c/ Retail sizes, under one pound.

Source: Computed from USDA farm price estimates, f.o.b. prices reported in Quick Frozen Foods, and retail price data collected for the U. S. Agricultural Marketing Service by the Bureau of Labor Statistics, U. S. Department of Labor.

and quality. The determining or primary demand is the demand of consumers for the final product or products. The quantity demanded at any time depends principally on price, level of purchasing power (income), and prices of competing products. In addition, there are random variations due to the net effect of largely unmeasurable or individually minor factors such as weather, structure of income, and fluctuating preferences. Demand may also shift systematically over time with changes in tastes and habits and, as observed in the previous section, may vary widely among geographic regions.[1/]

By subtracting distribution and transfer charges there is derived from the consumer demand equations a set of demand functions facing processors of each vegetable in each producing region. Under competitive conditions, the set of demand functions and the transfer costs among regions are sufficient to determine an optimum pattern of distribution and corresponding equilibrium regional prices for each possible set of regional supplies and values of income and other demand factors. The determination of the set of prices corresponding to any set of regional supplies involves a multimarket equilibrium solution and there is no single mathematical expression that directly relates regional price to regional supplies and other factors.[2/]

Growers in each region are faced with demand for the raw product in both processing and fresh markets. In a perfectly competitive economy with complete knowledge, the farm demand of processors would be determined by subtracting processing and assembly costs from the processor equilibrium prices corresponding to each possible set of regional outputs. In practice, the relationship is complicated by the fact that processor-grower contracts must be made on the basis of expected future demands, rather than current known demand, and must take account of inventory conditions and uncertainties as to production in other regions. Moreover, grower-processor contractual agreements frequently involve allowances, credit arrangements, technical assistance, and other factors that are difficult to translate into price.[3/] Thus, although the farm demand is, in fact, a derived

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1/ Differences in per capita consumption among regions do not alone necessarily indicate differences in preference, or in the level of the demand curve, since prices may also differ regionally.

2/ The relation can, of course, be stated mathematically in the form of a function involving prices, quantities and other factors to be maximized or minimized subject to certain restraints. For a concisely stated example see, Lee F. Schrader and Gordon A. King, "Regional Location of Beef Cattle Feeding," Journal of Farm Economics, February 1962, pp. 64-81.

3/ See, for example, Robert H. Reed, Survey of the Pacific Coast Frozen Fruit and Vegetable Processing Industry, Calif. Agr. Exp. Sta., Giannini Foundation Report No. 198, September 1957, pp. 21-24.

demand, the derivation is exceedingly complex. Over time, some of the uncertain factors may be expected to average out and, under competitive conditions, subtraction of processing and assembly charges may give a reasonable approximation to the expected farm level demand.

The Empirical Problem

The discussion above suggests that measurement of demand relationships might logically begin at the regional retail level. However, continuous series of regional consumption data for frozen vegetables do not exist and such retail prices as are available cover only a very short period and very few areas.

Regional and United States average f.o.b. processing plant prices and series on United States average per capita consumption of most vegetables are available for the postwar years. Although we have seen that demand at the processing level actually involves rather complex relationships among sets of prices and quantities, estimates of the relation of average f.o.b. price to total per capita consumption or sales may yield some useful demand approximations. Such estimates are, of course, influenced by variations in regional output and the associated variations in patterns of distribution. Where the regional shares of total output follow a significant trend, the weighted average of regional prices may vary systematically and estimates based on aggregate data may be biased. It is argued later that the magnitude of such bias probably is not large for the commodities considered.

One of the most serious problems encountered in this analysis is the tendency of theoretically independent variables to move together because of strong trend factors. For example, while f.o.b. prices of frozen vegetables have moved generally downward, both per capita consumption and income have been moving upward. Because of this multicollinearity it is most difficult, in a time series analysis, to determine how much of the increased consumption is associated with changes in price and how much with income. One approach to the problem is to proceed in two stages. First, an income-consumption relationship is estimated from cross-section data on per capita consumption of families in different income classes. The resulting coefficient is then treated as a parameter in the more general time series analysis.[1/] Such a procedure is followed in the present study.

1/ For a discussion of the statistical consideration involved and examples of application of this procedure see, Richard Stone, Measurement of Consumers Expenditure and Behavior in the United Kingdom, 1920-1938, Volume 1, Cambridge: Cambridge University Press, 1954, especially pp.303-305. See also, Lawrence, R. Klein, An Introduction to Econometrics, Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1962, pp. 52-74.

Cross-Section Analysis

Cross-section data pertain to a single time period and show household or per capita consumption of various commodities for families with a wide range of socioeconomic characteristics. Income is the principal characteristic considered, but other factors such as family size, social class and the like may be important.

There are three major sources of cross-section data involving frozen vegetables: a 1950-51 Bureau of Labor Statistics study of Family Expenditures for Food, Beverages and Tobacco, the United States Department of Agriculture Household Food Consumption Survey conducted in 1955, and more recently, some regional sales surveys conducted by Harold L. Franklin for the trade magazine, Quick Frozen Foods for 1958, 1959, and 1960.[1/] Consumption data given in the United States Department of Agriculture study are in both physical and value terms, with specific figures for seven vegetables. The Quick Frozen Foods and the BLS surveys on the other hand, measure consumption in dollar terms, with more aggregation of vegetables. Income-consumption relationships based on the 1955 USDA survey data are used in the time series analysis that follows. Estimates based on the other two studies may also be of interest, however, and therefore are discussed very briefly.

BLS Survey

The BLS study reports average expenditures per family for a seven-day period during the spring of 1951. Expenditures are reported for selected frozen vegetables for 91 cities, together with information on average income, average household size, and other variables. Expenditures on total frozen vegetables are also given for families falling in each of nine income classes, detailed by family size and grouped into nine classes of cities.[2/]

The data for individual vegetables by cities appeared spotty and no attempt was made to derive relationships from these values. Aggregation of all expenditures

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1/ A substantial amount of very detailed family consumption data on a continuing basis is available from the Michigan State University Consumer Panel. However, the data pertain only to a single city and were considered too geographically limited for inclusion in this study. See James D. Shaffer, Consumer Purchase Patterns for Individual Fresh, Frozen and Canned Fruits and Vegetables, MSU Consumer Panel 1952-1958, MSU Consumer Panel Bulletin No. 8, Michigan State University, Department of Agricultural Economics, 1962.

2/ U. S. Bureau of Labor Statistics, Study of Consumer Expenditures, Income and Savings, Vol. XII, Detailed Family Expenditures for Food, Beverages and Tobacco, Wharton School of Finance and Commerce, University of Pennsylvania, 1957.

on frozen vegetables by cities provided a geographic cross section which produced some inconsistent and generally unsatisfactory estimates of the income-consumption relationship. These are discussed with the Quick Frozen Foods study which also involves geographic cross-section data.

Least squares regressions were obtained for the cross-section data arranged by income class for each of the nine city classes and for each family size, as well as all families combined. All values were expressed on a per capita basis and regressions were fitted in logarithms.[1/] The results are summarized in Tables 9 and 10. Table 9 gives the details of the individual regressions and Table 10 shows simple averages of elasticities for various regional and family size groupings.

The elasticity coefficients -- the b coefficients in the tables -- show the percentage change in per capita expenditure associated with a one percent change in per capita income. For example, for the sample of families included in the study, each one percent increase in income was associated with a .86 percent increase in per capita expenditure for one-person families in large cities in the north, a .75 percent increase for two-person families in northern suburbs, and so on. The elasticities appear to increase with size of family, especially the families with five or more persons. Elasticities also were higher for small cities than for large cities and suburbs. Other regional and city differences shown are of doubtful significance because of small and incomplete samples. The simple average of expenditure elasticities by family size is 1.05 or 1.08, depending on the method of averaging.[2/] This compares fairly closely with the average elasticity of .96 for the regressions based on all family sizes combined. In view of the modest correlations for many of the regressions and the incomplete sampling, all of these estimates should be regarded as rough indicators of general relationships, rather than precise estimates.

USDA Household Food Consumption Survey

Economists in the U.S. Department of Agriculture have conducted a number of analyses based on the 1955 Household Food Consumption survey data. A study by

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1/ This, of course, is only one of several functional forms that might have been used. It might be argued that a semilogarithmic function would be more appropriate since it leads to declining income elasticity with higher incomes. Both log and semilog functions are fitted to the USDA data. The log functions have the advantage of giving income elasticities directly, which facilitates comparisons. The difference in results with the two forms is not large.

2/ These differences arise in averaging because of the incomplete data for some regions.

TABLE 9

Estimates of Income-Expenditure Elasticities for Frozen Vegetables Based on 1951 Bureau of Labor Statistics Survey Data

City class and family size	Constant term (a)	Elasticity coefficient (b)	Standard error of b (S_b)	Correlation coefficient (r)
Large cities - north				
1	- 1.954	.859	.180	.906
2	- 2.461	1.010	.094	.971
3	- .993	.559	.222	.690
4	- 1.754	.786	.221	.802
5 or more	- 2.563	.998	.157	.933
All families	- .679	.759	.120	.923
Suburbs - north				
1	- .574	.476	.182	.760
2	- 1.611	.751	.126	.913
3	- 1.762	.829	.200	.862
4	- 2.157	.976	.057	.992
5 or more	- 3.993	1.501	.345	.890
All families	- .633	.783	.109	.939
Small cities - north				
1 a/				
2	- 1.675	.723	.487	.553
3	- 1.427	.680	.217	.814
4	- 2.236	.916	.243	.860
5 or more a/				
All families	- 2.312	1.237	.196	.922
Large cities - south				
1	- 1.984	.855	.239	.668
2	- 1.789	.821	.093	.958
3	- 4.668	1.699	.223	.959
4	- 1.618	.758	.387	.596
5 or more	- 5.473	1.928	.358	.924
All families	- 1.713	1.095	.268	.840
Suburbs - south				
1 a/				
2 a/				
3	- 3.322	1.278	.430	.799
4 a/				
5 or more a/				
All families	.860	.317	.233	.456
Small cities - south				
1 a/				
2	- 1.101	.586	.416	.630
3	- 4.450	1.626	.177	.983
4 a/				
5 or more a/				
All families	- 4.038	1.779	.366	.878
Large cities - west				
1	- .356	.300	.299	.409
2	- 1.797	.755	.307	.681
3	- 1.311	.635	.142	.860
4	- 2.490	.988	.226	.872
5 or more	- 4.079	1.458	.486	.802
All families	- 1.076	.857	.130	.928
Suburbs - west				
1 a/				
2 a/				
3	- 2.141	.898	.525	.650
4 a/				
5 or more	- 6.163	2.187	.637	.864
All families	- .033	.552	.231	.671
Small cities - west				
1	- 2.969	1.074	.273	.892
2	- 2.808	1.061	.316	.785
3	- 2.574	.961	.419	.716
4	- 4.318	1.517	.345	.910
5 or more	- 6.475	2.131	.873	.774
All families	- 2.565	1.281	.271	.872

a/ Data too incomplete for analysis.
Source: Computed from data obtained in the 1951 BLS Study of Consumer Expenditures, Income and Savings.

TABLE 10

Average Income-Expenditure Elasticities for Frozen Vegetables by Region, Family Size, and City Class, Based on 1951 BLS Survey Data

	Number of persons per household					Average	All families
	1	2	3	4	5 or more		
North	.668	.828	.690	.893	1.249	.865	.926
South	.855	.703	1.534	.758	1.928	1.156	1.064
West	.687	.908	.832	1.252	1.925	1.121	.897
Average	.737	.813	1.018	.968	1.701	1.047	.962
Large cities	.671	.862	.964	.844	1.462	.961	.904
Suburbs	.476	.751	1.002	.976	1.844	1.010	.551
Small cities	1.074	.790	1.089	1.217	2.131	1.260	1.432
Average	.740	.801	1.018	1.012	1.812	1.077	.962

Source: Computed from Table 9.

Reese is by far the most detailed with respect to the commodities considered here.[1] However, the study does not include specific estimates of income elasticities, as such. Another study by Rockwell develops estimates of income elasticities for total frozen vegetables by income group separated into farm and nonfarm classes.[2] This breakdown, although desirable for many purposes, makes the results awkward to use in the present analysis. The USDA data have therefore been analyzed further to obtain estimates in a form that is more convenient for purposes of this investigation.

The USDA cross-section data pertinent to this study consist of reports of household consumption of seven frozen vegetables for a single week during April-June, 1955, for families falling in nine different income classes (income after taxes). These data are given for the United States and four geographic regions and by rural-urban classifications. Average family size is also given for each income class. Both consumption and income were converted to a per capita basis and least squares regressions fitted for each grouping. Consumption, in pounds, was the dependent variable in all cases.[3] Values were expressed initially in logarithms, with a semilog modification introduced later.

The set of equations fitted singly to United States data for families of all urbanizations is summarized in Table 11. As for the BLS study, the elasticity coefficients -- the b coefficients in the table -- show the percentage change in per capita consumption associated with a one percent change in per capita income. For example, for the sample of families included in the study, each one percent increase in income was associated with a .98 percent increase in per capita consumption of snap beans, .50 percent for sweet corn, .816 percent for all vegetables, and so on. All coefficients are highly significant by the usual statistical measures.

The elasticity estimate for all frozen vegetables (.816) is larger than obtained by Rockwell.[4] His estimates by income class and rural-urban classification

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1/ Reese, Robert B., op. cit.

2/ Rockwell, George R., Jr., Income and Household Size: Their Effects on Food Consumption, USDA, Agricultural Marketing Service, Marketing Research Report No. 340, June 1959.

3/ Average size of family was also introduced as an explanatory variable in the initial analysis. The coefficient for this variable was positive but nonsignificant. Rockwell, loc. cit., obtained negative coefficients in his study based on individual household data. Classifying families by income per household, as in the case of the data used here, apparently results in a high positive correlation between income per family member and size of family since large families tend to have more dollar earners. The correlation between these two variables in this study was .91. Because of its nonsignificance and questionable sign, family size was dropped as a separate variable in the analysis.

4/ Rockwell, op. cit.

TABLE 11

Estimates of Income-Consumption Elasticities for Frozen Vegetables Based on United States Families of all Urbanizations a/

Vegetable	Constant term (a)	Elasticity coefficient (b)	Standard error of b (S_b)	Correlation coefficient (r)
Lima beans	- .165	.471	.024	.943
Snap beans	-1.870	.980	.048	.948
Broccoli	-1.716	.935	.050	.936
Peas	-1.655	1.003	.021	.981
Spinach	-1.641	.881	.043	.945
Corn	- .549	.501	.031	.917
Other vegetables	-1.393	.931	.022	.974
Total vegetables	- .398	.816	.014	.993

a/ Based on least squares regression of per capita consumption on per capita income for nine income classes. Equations were fitted having the form log Y = a + b log X where Y is per capita consumption in one week, X is per capita annual income and a and b are the coefficients given above. The elasticity coefficient shows the expected percentage change in per capita consumption associated with a one percent change in per capita income.

Source: Computed from data in the 1955 USDA Household Food Consumption Survey.

are as follows:

	Low	Medium	High
Nonfarm households	.67	.60	.47
Farm households	1.80	.62	.62

The high elasticity for the low income farm households is not likely to carry enough weight when combined with the other groups to give an average value of .816.1/ The differences in results appear to be largely due to differences in the method of treating the data. Rockwell had access to individual household data and his estimates are based on these values rather than group averages, with regressions fitted separately to the classes indicated above.

In view of the differing estimates it seemed desirable to carry the present investigation a bit farther. Regressions were fitted, as in Table 11, to the consumption data for total frozen vegetables for farm and nonfarm groupings and for each of the four geographic areas into which the survey data are separated. Since there is a suggestion in Rockwell's study of declining income elasticity as income increases, regressions were also fitted in semilog terms, with only income in logarithms. This form also proved useful in the later time series analysis. The results are summarized in Table 12.

The generally lower values of these elasticity coefficients (logarithmic functions) are somewhat startling and cast doubt on the validity of .816 figure obtained in the aggregate. For the regional estimates, only the South shows an income elasticity higher than .816. The population weighted average of the regional elasticities is only .73.2/ For the urbanization groupings, all estimates are below the value obtained in the aggregate. The weighted average elasticity is .59.

The semilog functions produce equations that on the surface appear to reverse the slope relationships among the regional and urban groupings. However, the curves actually are very similar over the range of the data, the major difference occurring in the equation for the South. These equations have income elasticities that

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1/ The standard error of this value (1.80) also was quite large, Rockwell, op. cit.

2/ Since the equations are fitted in logs they cannot be conveniently averaged into a single equation with a single elasticity coefficient that will predict United States totals. With fixed income distribution, average coefficients would predict means of logarithms or geometric means. It would then be necessary to determine the relation between geometric and arithmetic means. See Klein, op. cit., especially pp. 104-105. The average elasticity may, however, serve as a reasonable approximation to the aggregate value.

TABLE 12

Income-Consumption Relationships for Total Frozen Vegetables by Urbanization and Regional Groupings

	Logarithmic functions[a]				Semilogarithmic functions[b]			
	Constant term (a)	Regression coefficient (b)	Standard error of b (S_b)	Correlation coefficient (r)	Constant term (a)	Regression coefficient (b)	Standard error of b (S_b)	Correlation coefficient (r)
United States, by urbanization								
Urban	- .492	.549	.101	.899	- .494	.220	.050	.858
Rural nonfarm	- 1.230	.716	.194	.813	- .210	.104	.041	.696
Farm	- 1.040	.581	.059	.966	- .102	.054	.013	.845
Average[c]	- .731	.588			- .384	.174[d]		
Regional grouping								
Northeast	.559	.535	.097	.902	- .380	.182	.038	.875
North Central	.328	.561	.191	.743	- .409	.178	.058	.759
South	- 1.442	1.135	.094	.977	- .453	.197	.031	.924
West	.487	.562	.162	.816	- .688	.282	.068	.862
Average[c]	- .104	.727			- .447	.197[e]		

a/ Functional form log Y = a + b log X where y is per capita consumption and X is per capita income (after taxes).
b/ Functional form Y = a + b log X.
c/ Weighted by population.
d/ Income elasticity is .55 for per capita income of $1,000, .50 for $1,200 and .46 for $1,400.
e/ Income elasticity is .59 for per capita income of $1,000, .54 for $1,200 and .50 for $1,400.
Source: Computed from data in the 1955 USDA Household Food Consumption Survey.

are near, but slightly below the log functions in the middle income ranges (from $1,000 to $1,400 per capita).

The higher value for the elasticity based on aggregate United States data (.816) appears to be due largely to regional and rural differences in preference that are correlated with income. Southern families tend to consume less frozen vegetables than their income counterparts in other regions. When households are tabulated nationally the lower income classes are heavily weighted by Southern families, thus attributing to income, some of the consumption variation that is actually associated with other factors. This tends to tip the total income-consumption relation unduely and so to suggest an income elasticity that is "too high."

The data for individual vegetables become rather "thin" when households are grouped by region and urbanization and the income-consumption relationships appear somewhat erratic. The data are more stable for urban families, however, since they account for about two-thirds of all households in the survey. Individual equations for this grouping are summarized in Table 13. The elasticities again are all substantially lower than obtained for the aggregate grouping.

Quick Frozen Foods Survey

In 1958 the magazine, Quick Frozen Foods, began a series of surveys of frozen food sales in metropolitan markets throughout the United States. The survey was updated and expanded in 1959, and in 1960 institutional sales were included.1/ Of relevance to this study, the surveys included estimates of dollar sales of frozen fruits and vegetables by areas and states, together with data on population, income, and size of household (the latter not given in 1958). Except for some initial explorations, the present analysis used only the 1959 and 1960 data.

As with the USDA and BLS data, the variables were expressed on a per capita basis, and the relation of dollar sales to income and other variables was estimated by least squares regression. In this survey, however, families were grouped by regions or metropolitan areas, rather than by homogeneous income groups. Average per capita income and consumption vary substantially among regions.

The results of this analysis are given in Table 14. Four regressions were fitted to the 1959 data and four to the 1960 data. In each case per capita expenditures or sales is the dependent variable. Per capita income, average number of

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1/ A detailed account of the survey procedures has not been published. It is not possible, therefore, to evaluate the reliability of these data.

TABLE 13

Income-Consumption Elasticities for Frozen Vegetables,
United States Urban Families

Vegetable	Constant term (a)	Elasticity coefficient (b)	Standard error of b (S_b)	Correlation coefficient (r)
Lima beans	.482	.277	.076	.810
Snap beans	- .412	.513	.243	.624
Broccoli	-1.144	.775	.209	.814
Peas	- .923	.784	.109	.939
Spinach	- .599	.582	.250	.661
Corn	.237	.264	.111	.670
Other vegetables	- .303	.602	.080	.944
Total vegetables	- .492	.549	.101	.899

Source: Computed from data in the 1955 USDA Household Food Consumption Survey.

TABLE 14

Income-Expenditure Relationships for Total Frozen Fruits and Vegetables Computed from Quick Frozen Food Survey Data a/

Equation	Dependent variable b/	Constant term	Independent variable b/ coefficients c/: $\log X_1$	$\log X_2$	X_3	Correlation coefficient R
Food store expenditure, 1959						
(1) 100 metropolitan markets	$\log Y_1$	- 4.545	1.6005 (.1789)	-.6877 (.3668)		.725
(2) 48 states	$\log Y_1$	- 7.334	2.3282 (.1914)			.873
(3) 48 states	$\log Y_1$	- 5.848	1.8502 (.2473)		.1650 (.0868)	.924
(4) 48 states	$\log Y_1$	- 4.825	1.6553 (.2335)	-.7237 (.5698)	.1626 (.0312)	.926
Food store expenditure, 1960						
(5) 100 metropolitan markets	$\log Y_1$	- 4.113	1.4637 (.1889)	-.7029 (.3841)		.671
Institutional expenditure, 1960						
(6) 100 metropolitan markets	$\log Y_2$	- 4.583	1.4802 (.2640)	-.2986 (.5304)		.525
Total expenditures, 1960						
(7) 100 metropolitan markets	$\log Y_3$	- 3.981	1.4652 (.1863)	-.5517 (.3783)		.668
(8) 100 metropolitan markets	$\log Y_3$	- 4.544	1.5470 (.1387)			.659

a/ Quick Frozen Foods, E. W. Williams Publications, Inc., New York. Issues of March 1961 and March 1962.

b/ Explanation of variables:

Y_1 = Food store per capita dollar sales

Y_2 = Institutional per capita dollar sales

Y_3 = Total per capita dollar sales

X_1 = Per capita buying income (not defined in the survey report but believed to be essentially the same as personal disposable income)

X_2 = Average number of persons per household

X_3 = A dummy variable to allow for otherwise unexplained differences in expenditure levels between northern and southern regions

X_3 = 1 in the New England, Middle Atlantic, East North Central and Pacific states;

X_3 = 0 in all others.

c/ Figures in parentheses are standard errors.

persons per household, and a regional shift factor serve variously as the independent or explanatory variables. As before, income and expenditures were expressed in logarithms. Family size appeared to have some influence on per capita consumption and so was introduced as an additional variable. This further improved the fit but the standard errors of the regression coefficients for family size are fairly high.

Examination of a plot of the observations of state data suggested a difference in the level of expenditures between the Northern and Southern regions that was not related to income. A dummy variable (X_3) was introduced to account for this difference. No clear difference in level of the relationship among regions was detected in the metropolitan market data. This may be due to a rural influence in the state data which is not present in the metropolitan figures. Initially, the ratio of rural population to the total for each state was included as a variable but later was dropped because of its high correlation with average income, which led to statistically nonsignificant results.

Equations (1) and (4) indicate that in 1959 a one percent change in the regional level of per capita income, with other factors constant, was associated, on the average, with a 1.60 to 1.65 percent change in per capita food store sales. Per capita sales of frozen fruits and vegetables appear to decrease as family size increases, although the relation is not highly significant statistically. Each one percent increase in average family size was associated with roughly a .7 percent decrease in per capita sales.

In 1960, the QFF survey included institutional as well as food store sales for 100 metropolitan areas. The observations on frozen fruit and vegetable sales were not broken down by states. The regressions fitted to the metropolitan market data are given by equations (5) to (8) of Table 14.

Although the estimates of the income coefficients are highly significant, the overall percentage of variance explained is somewhat less than with the 1959 data. The expenditure elasticities (the income coefficients) are also reduced. As would be expected, average family size had little or no effect on institutional sales and the regression coefficient for this variable is not statistically significant. However, institutional sales were significantly related to income levels and the income-expenditure elasticity was approximately the same as for food store sales.

USDA, BLS, and QFF Results Compared

By now the reader has probably noted and may be puzzled by the differences in elasticities obtained in the three analyses. The BLS income-expenditure elasticities averaged about 1.0. Estimates of income-quantity elasticities based on the 1955 USDA data were less than 1.0 while the income-expenditure elasticities based on QFF data ranged from 1.46 to 1.65.

If prices are correlated with income and consumption, as would be the case if higher income families purchased better grades and qualities, the income-expenditure elasticity may be expected to be higher than the income-quantity elasticity.1/ Comparison of quantity and expenditure data from the 1955 USDA survey by income class does not show any correlation between income and expenditure per pound of frozen vegetables. Quantity and price data for frozen vegetables were not reported in the BLS survey, however, and it is possible that a price-income correlation may have existed. The analysis of USDA data by Rockwell based on individual family, rather than group observations gave generally higher elasticities for expenditures than quantity. The difference in time period could also be a factor, but the data are only four years apart.

In comparing results based on BLS and USDA data with the very high elasticities obtained from the QFF data it should be noted that the latter include expenditures on frozen fruits as well as vegetables. While this could account for some of the difference, a plausible hypothesis would suggest that both frozen fruit and vegetable price levels may have been higher in regions of higher per capita income because higher quality and higher value items were featured. This cannot be verified, however, since quantity and price data were not reported in the QFF and BLS studies. Imputed prices computed from USDA data did not appear to be correlated with regional variations in income, but the regional groupings were very broad and no very firm conclusions are possible from these calculations.

Of possibly greater importance in explaining these differences is the correlation of regional income levels with variations in unmeasured taste or habit factors. For example, the 1955 USDA survey shows that levels of frozen vegetable consumption in the South tend to be less than in the North for families with comparable incomes. Since average incomes in the South are typically below those of Northern areas a geographic cross section may attribute to income, consumption variations that are actually associated with other factors. If the dummy shift

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1/ For a more detailed discussion see, Herman Wold, Demand Analysis, New York: John Wiley and Sons, Inc., 1953, pp. 219-220, and S. J. Prais, and H. S. Houthakker, The Analysis of Family Budgets, Cambridge: University Press, 1955, pp. 108-124.

variable introduced does not fully account for the differences in levels the resulting estimate of the income elasticity will be biased upward.

As a further check on the type of results obtained from geographic cross sections, expenditures on frozen vegetables reported in the BLS study were totaled for each of the 91 cities included in that survey and least squares regressions fitted, as above, to city values of average per capita consumption and income. The results are summarized in Table 15. While the expenditure elasticities for individual city classes and regions are somewhat erratic and of low statistical significance, the values obtained for all cities are consistent with the results based on the QFF data. It would appear therefore, that geographic cross-section data on expenditures are subject to intercorrelation problems among influencing variables that may tend to produce rather biased estimates of income-expenditure relations and especially the income-quantity elasticities. Evaluated both in relation to this problem and in terms of statistical significance, the estimates based on the 1955 USDA study seem the most satisfactory of the three sets, particularly for use in further time series analysis.

Time Series Analysis

The development of a statistical model to estimate demand relationships involves (1) specification of the variables of the problem and the set of relations among them, (2) specification of the statistical properties of the model, and (3) improvising, and evaluating the validity of such improvisions, as a consequence of data limitations and computational difficulties. Some of the significant data limitations and computational problems were noted at the outset. Lack of adequate retail price data has restricted the analysis to the f.o.b. plant level and high multicollinearity among prices, consumption, and income has led to an attempt to use a combination of cross-section and time series analysis.1/ The variables believed to be particularly important were also discussed, in a general way, at the outset. We are concerned now with the development of a plausible specification of relationships that can be estimated within the limitations imposed by the available data and applicable statistical methodology.2/

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1/ The correlation between per capita income and total frozen vegetable consumption, for example, was approximately .98.

2/ For some interesting brief comments on the general problem of deriving and testing statistical models of demand see, Sidney Hoos and George M. Kuznets, Impacts of Lemon Products Imports on Domestic Lemon Market, Calif. Agr. Exp. Sta. Giannini Foundation Research Report No. 254, pp. 43-44.

TABLE 15

Income-Expenditure Elasticities Based on BLS Survey Geographic Cross-Section Data

Equation	Number of observations	Constant term (a)	Regression coefficient (b)	Standard error of b (S_b)	Correlation coefficient (r)
(1) Large cities - north	20	- 4.830	2.081	.703	.572
(2) Large cities - south	14	- 2.849	1.458	.802	.465
(3) Large cities - west	15	-12.659	4.516	1.520	.636
(4) All large cities	49	- 4.166	1.854	.580	.423
(5) Small cities - north	14	-14.962	5.342	1.324	.759
(6) Small cities - south	8	- 3.074	1.487	2.960	.201
(7) Small cities - west	19	- 1.559	.952	.905	.247
(8) All small cities	41	- 3.521	1.611	.631	.378
(9) All cities	90[a/]	- 4.351	1.899	.412	.441

a/ No expenditures on frozen vegetables were reported for one small city in the west. Thus there are actually only 90 observations, rather than the full 91 in the survey.

Source: Computed from BLS survey data.

Since emphasis is on the formulation of demand relationships, we will not be concerned with supply behavior except insofar as it may be relevant to the estimation of demand parameters.

Model Specification

As noted earlier, frozen vegetables are packaged in both retail and institutional sizes and in various grades and styles, with associated differences in price per pound. These prices tend to behave similarly with respect to major economic forces and we will be concerned here with estimation of changes in the average or typical level of the prices. The "average" price received by freezers of a particular frozen vegetable, P^i_{Ft}, during period t is assumed to depend on the per capita quantity of vegetable placed on the market, Q^i_{Ft} (which is essentially the same as per capita consumption), per capita sales of all other competing frozen vegetables, Q^o_{Ft}, per capita sales of competing canned and fresh vegetables, Q_{Ct} and Q_{Rt}, on income levels, I_t, on trend factors which may shift the demand, represented by time, T, and on the regional distribution of production and other individually minor factors assumed to have the impact of a random disturbance, u_{it}.

(1) $P^i_{Ft} = f_i(Q^i_{Ft}, Q^o_{Ft}, Q_{Rt}, Q_{Ct}, I_t, T) + u_{it}$.

Although the total supplies of most frozen and canned vegetables available during a given time period tend to be predetermined, the quantities actually sold are determined simultaneously with prices and the amount of inventory carried into the next period. Thus the demand equations for frozen vegetables are a part of an interdependent system consisting of the set of demand functions for individual frozen vegetables, a similar set of functions for canned and fresh vegetables (as in equation 1) and a set of demand functions for frozen and canned carry over stocks.

The demand for carry over stocks, C_{it}, involves both transaction and speculative motives. Transaction stocks are maintained to meet the needs of retailers and other customers as part of the normal operations of a continuing business firm. Speculative stocks are quantities in excess of transaction needs, held to avoid reducing current prices, with the expectation that they can be sold at satisfactory prices in the following period. The problem is one of allocating sales among markets where the markets are separated by time. The rules followed in making these allocation decisions are not known. It seems reasonable, however,

that the amount of carry over stocks for a particular vegetable may be influenced by current price of the vegetable, the total stocks on hand immediately after processing (at the beginning of the consumption period), S_t, and other unspecified factors represented by v_{it}. For a particular frozen vegetable this would be expressed symbolically as

$$(2) \quad C^i_{Ft} = h_i(P^i_{Ft}, S^i_{Ft}, S^o_{Ft}, S_{Ct}) + v_{it}.$$

Similar expressions would be required to represent carry over demand for canned vegetables. The model is completed by including a set of identity equations of the form

$$(3) \quad Q_{it} = S_{it} - C_{it}.$$

Specific supply equations are not included in this model since current period supply is regarded as predetermined by events in the previous period. Under these conditions estimates of total supply response are not involved in the estimation of the demand parameters.

Estimation of Demand Equations

Although a simultaneous equation approach to estimation would appear appropriate there are practical (and perhaps controversial) reasons for preferring single equation estimates of the demand parameters. One source of difficulty with the full model is in defining the form of the storage demand function in terms amenable to estimation. It seems unlikely that this equation will be linear. As the current price increases the quantity of carry over stocks may be expected to decline rapidly at first and then very slowly as they reach the level of normal transaction stocks. An asymptotic function would perhaps be appropriate, but difficult to handle statistically.

The categorization of some of the variables as endogenous (mutually determined) or exogenous (determined outside the system) is also subject to interpretation and, depending on the choice, affects the identification of the parameters of the model. Carry over stocks are highly correlated with the level of total supplies (a predetermined variable) and as a practical matter the quantity marketed (and per capita consumption) may appear much as an exogenous variable in relation to the f.o.b. processor price. These considerations, coupled with intercorrelation

problems, to be discussed shortly, suggest that the forecasting efficiency of single equation least squares may be at least no worse than any of the several simultaneous estimation approaches that might be used.

Preliminary explorations indicated that price and consumption movements have been so highly correlated among the several frozen vegetables that it is virtually impossible to determine the separate influence of any single vegetable. Consequently, all frozen vegetables have been aggregated and treated as a single commodity. Although further decomposition would be desirable, the individual frozen vegetables seem to be close substitutes and the aggregation is perhaps only a degree broader than is common for many single commodities with several sizes and grades.1/ To predict prices of individual vegetables, the aggregate demand function is later adapted to the observed behavior relationships among commodities.2/

Given these simplifications, the demand relationship to be estimated takes the form

$$(4)\quad P_{Ft} = b_o + b_1 Q_{Ft} + b_2 Q_{Rt} + b_3 Q_{Ct} + b_4 \log I_t + b_5 T + u_t$$

where the subscripts F, R, and C refer to frozen, fresh, and canned and all variables are in per capita terms as defined previously. Also from the previous discussion it is argued and assumed that the model approximately satisfies the usual statistical specifications for single equation regression -- a dependent variable related to a set of given or predetermined variables and a random disturbance that is normally distributed independently over t, with zero mean and fixed variance.

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1/ Consumption was aggregated in terms of frozen product weight by simple addition. This seems reasonable since a 10-ounce package of (say) frozen broccoli would be about equivalent in consumption to a 10-ounce package of other frozen vegetables. The aggregate price is a commodity weighted average, equivalent to dividing total revenue by total pounds consumed. The alternative of using fixed weight indexes seemed less desirable since the vegetables are being treated as a homogeneous commodity. The results would not be greatly different in either case. Average prices for retail sizes were used as representative series. Combining prices for both retail and institutional sizes would introduce some extraneous influence if the proportions changed since institutional prices are somewhat lower than prices for retail sizes due to lower handling costs.

2/ Regressions were also fitted with price of each vegetable as a function only of its own per capita consumption. The results, were less satisfactory, from a statistical point of view, and so are not reported here.

This particular functional form was selected after some preliminary graphic exploration. Expressing income in logarithms allows for a decreasing income elasticity with higher levels of income. The trend factor T is included to allow for changing consumption habits and preferences which may have shifted the demand function gradually to the right, beyond that accounted for by changes in income. A nonlinear trend and the percentage of families owning refrigerators are also considered as alternative variables associated with this shift.

Unfortunately, the treatment of frozen vegetables as a single commodity does not solve all of the problems of multicollinearity among the explanatory variables. Per capita consumption of frozen and fresh vegetables have been highly negatively correlated and the trends in both have been correlated with the trend in per capita income and with time. The nature of these associations since 1947 is illustrated in Figure 4.

Because of this high degree of multicollinearity it is impossible to obtain good (statistically unbiased) estimates of the structural parameters of the demand equation. However, we can obtain some indication of the likely range within which the parameter values may lie and can estimate some functional relationships which may be useful for prediction and analysis under specified conditions. The procedure followed is first to examine the relation between prices and consumption of frozen vegetables assuming that the coefficients of all other explanatory variables in equation 4 are zero. Constraints and modifications are then introduced which may cast some additional light on the empirical nature of the demand relationship.

Two variable models.--Figure 5 shows the relation of average price of frozen vegetables to per capita consumption for the period 1947-1961, with other variables omitted (assumed to have zero coefficients). The least squares regression equation fitted to these data is also given in the diagram. The term r is the correlation coefficient, S_b is the standard error of the regression coefficient and d' is the Durbin-Watson statistic. Based on the latter, the hypothesis of zero serial correlation of residuals would not be rejected at the five percent level of significance. The equation suggests that if we ignore other factors, on the average an increase of one pound in per capita consumption has been associated with a decrease of about one cent per pound in the average price.

Figure 6 shows the same relationship with price deflated by the Bureau of Labor Statistics Consumer Price Index for all commodities. The dependent variable

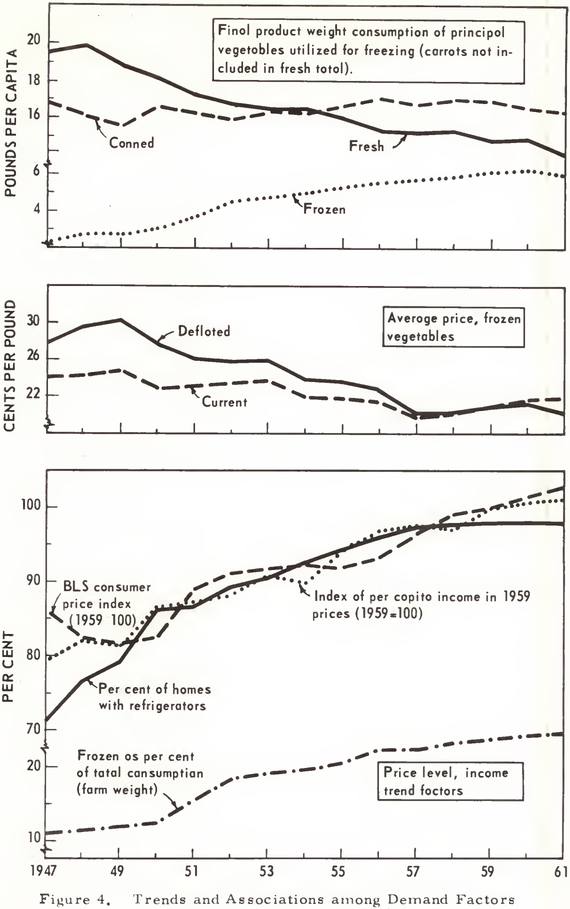

Figure 4. Trends and Associations among Demand Factors for Frozen Vegetables, 1947-1961.

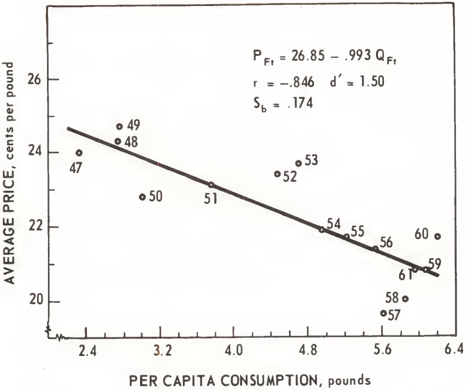

Figure 5. Unadjusted Relation of Average Price of Frozen Vegetables (P_{Ft}) to Total Per Capita Consumption of Frozen Vegetables (Q_{Ft}), 1947-1961.

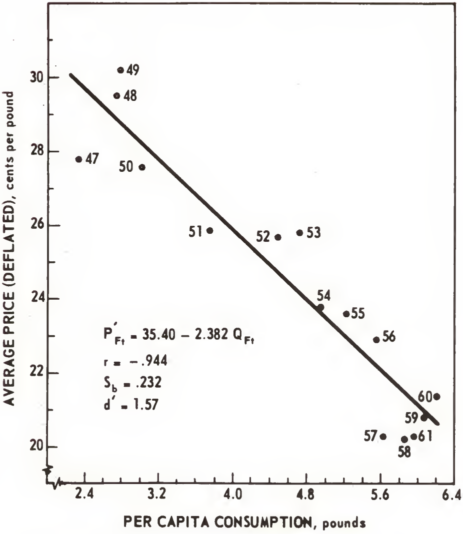

Figure 6. Unadjusted Relation of Deflated Average Price of Frozen Vegetables (P'_{Ft}) to Total Per Capita Consumption (Q_{Ft}), 1947-1961.

is average price of frozen vegetables relative to a measure of the general price level for all commodities. Since the latter has been increasing (Figure 4) and the former declining, the deflated price decreases more rapidly in relation to per capita consumption than does the actual price. Statistically, there is little basis for choice between the two regressions. However, the deflated price series seems more appropriate for a subsequent adjustment involving a cross-sectionally estimated income coefficient.

The regressions of Figures 5 and 6 provide what might be regarded as lower limits to the slope of the demand function for frozen vegetables. In view of the directions of the trends shown in Figure 4, allowance for variations in any of the additional explanatory variables, with logical sign, would tend to increase the estimated slope of price on per capita consumption of frozen vegetables. To illustrate, income has been increasing while price has decreased. Assuming a positive income coefficient, to achieve the same actual price decline would have required a greater decline in relation to consumption to offset the effect of increasing income. The situation with respect to trend is similar since it is reasonable to expect the trend in demand to be positive -- frozen vegetables being a relatively new product. Per capita consumption of fresh vegetables, the main competing product, has steadily declined. The sign of this variable in equation 4 would logically be negative. Allowance for changes in this factor would further increase the slope of the frozen demand relation.

Constrained regression models.--As was noted earlier, one means of estimating time series relationships when the explanatory variables are highly correlated is to obtain information about certain of the coefficients from other sources, such as cross-section studies.1/ This procedure is followed here with respect to the income coefficient.

An average coefficient based on the semilog figures in Table 12 is regarded as the best estimate of the income-consumption relation. This value (.185) is multiplied by 52 weeks to approximate the change in annual per capita consumption in relation to (the log of) annual per capita income. The latter figure (52 x .185 = 9.62) is entered as a constraint in the time series analysis. Values above and below the 9.62 figure were also considered in the exploratory analysis but are not included here since they are considered less likely and did not greatly alter the results.2/

1/ For other examples and discussion see, Wold, op. cit. and Stone, op. cit.

2/ One of the limitations to using cross-section estimates in time series analysis is that we cannot be sure that the consumption response to income changes (Continued)

The constrained regression procedure is complicated slightly by the fact that we wish to treat price as the dependent variable, for reasons noted previously, and the cross-section income coeffficient pertains to the relation between consumption and income. If equation 4 is transposed with Q_{Ft} dependent it is evident that the cross-section income coefficient, E, is equivalent to

$$- \frac{b_4}{b_1} \text{, or } b_4 = - b_1 E \ .$$

Substituting in (4) with b_2, b_3 and b_5 assumed to equal zero for the moment, gives

$$(5) \quad P_{Ft} = b_o + b_1(Q_{Ft} - E \log I_t) + u_t$$

or

$$P_{Ft} = b_o + b_1 Q'_{Ft} + u_t \ .$$

The procedure reduces to estimating the parameters of an equation with a single explanatory variable, Q'_{Ft}. Annual values of this variable are computed by subtracting log of per capita income, multiplied by the conditional income coefficient, from per capita consumption. Income is expressed as an index (1959 = 1.0) in terms of 1959 dollars.

The adjusted estimates are given and illustrated in Figure 7. As would be expected, the absolute slope of the price-consumption relationship is increased. The relation indicates that after adjusting for increases in income, and assuming other variables to have had no net influence on price, each increase of one pound in per capita consumption has been associated on the average, with a decrease of 3.1 cents in the average "real" price per pound.

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1/ (Continued from page 40) will be the same in time as among households. Levels of household consumption are associated with a wide variety of socioeconomic characteristics, some of which may be highly correlated with income. These correlated factors may not appear to have separate significance in a cross-section study and their influence thus may be represented by the single variable, income. This would not be a serious problem if the correlation between income and socioeconomic factors were the same in time as in cross section. Unforunately, this is not the case. While income levels may vary substantially over time, family size, education, racial factors, and the like change slowly. It is possible, therefore, that a cross-section income elasticity may attribute too much influence to income in a time series application. For additional discussion of possible limitations in using cross-section estimates in time series analysis see, Edwin Kuh, "The Validity of Cross-Sectionally Estimated Behavior Equations in Time Series Applications," Econometrica, Vol. 27, No. 2, April 1959, pp. 197-214; Stefan Valavanis, Econometrics, New York, McGraw-Hill Book Co., Inc., 1959, pp. 192-195; and Klein, op. cit.

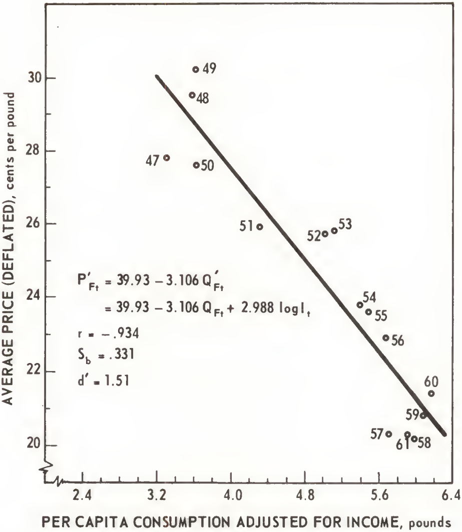

Figure 7. Relation of Deflated Average Price of Frozen Vegetables (P'_{Ft}) to Total Per Capita Consumption Adjusted for Changes in Income Levels (Q'_{Ft}), 1947-1961.

As noted previously the variables neglected so far -- changes in supplies and consumption of competing products and gradually changing tastes and habits -- have been highly correlated with consumption of frozen vegetables. The estimated price-consumption coefficient thus may be biased downward for purposes of predicting changes in prices from changes in consumption <u>with competing products and tastes held constant</u>. On the other hand, if the association between these omitted variables and per capita consumption of frozen vegetables remains in the future as it has in the past, the equations developed may provide a reasonable basis for price forecasting.

While we have no way of knowing whether or not and how long these associations may continue, there is a suggestion in the trends illustrated in Figure 4 of some continuation in the gradual shift from fresh to frozen vegetables. Frozen vegetable consumption has increased from 10 percent of the total in 1947 to nearly 25 percent in 1961.[1/] Increases in frozen consumption have continued to be matched, for the most part, by decreases in fresh consumption, and it seems reasonable to expect a continuation of the substitution among these products in the future.

There is, however, some likelihood that the level of demand for frozen vegetables has been increasing at a decreasing rate and the rate of shift in the future may be less than in the past. A plausible hypothesis would suggest a fairly rapid shift in the formative and development years of the late 1940s and early 1950s followed by a declining rate of change as the market began to mature in later years. Some indication of this is obtained by examining the scatter of observations in recent years -- say since about 1953 or 1954 (Figure 7). A curve fitted to these observations would be somewhat steeper than obtained for the total period (a slope of about -7.0 compared with -3.1) and would be consistent with the hypothesis advanced above.

To obtain a more specific indication of the possible nature of the trend relation a value of -7.0 has been assigned to the slope of the price consumption relationship. Given this restraint, and neglecting competing products as discussed above, we obtain

$$(6)\quad P'_{Ft} = a_o - 7.0Q'_{Ft} + f(T) + u_t$$

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1/ These percentages refer to the nine principal vegetables utilized for freezing, rather than total vegetables. See Appendix Table A2.

where f(T) is some nonlinear trend function. This may be rewritten in the form

$$(7) \quad Z_t = P'_{Ft} + 7.0Q'_{Ft} = h(T) + u_t \ .$$

Values of Z_t are plotted against time (T) in Figure 8 and against the percent of households with refrigerators in Figures 9 and 10. The trend line shown in Figure 8 is a quadratic which has a maximum value in 1959. The downturn in the curve would not appear to have any real significance and the slope of the trend line might be assumed to be zero from 1959 on. The alternative of measuring the trend influence by the percent of families owning refrigerators has some advantage in that the function does not turn down and there is less indication of serial correlation in the residuals. A one-year lag in this percentage gave somewhat better statistical results than current year values (Figure 10). In no case is the hypothesis of zero serial correlation of residuals rejected at the 5 percent level of significance.

It must be stressed that the value -7.0 assigned to the price-quantity slope, although reasonable and consistent with recent experience, was arbitrarily selected. Other values near this figure would have given equally as good a statistical fit, but with different coefficients. The general form of the relationship would be similar, however.

Summary of demand estimates.--Approximations to the demand relations for frozen vegetables are obtained by rearranging the regressions of Z on the trend variables. These equations, along with the several other demand estimates, are summarized in Table 16. Figures in the column on the far right are price flexibilities for 1959-61 average values of the explanatory variables. They show the percentage change in price associated with a one percent change in per capita consumption.

Evaluated only in terms of statistical measures relative to past behavior, the first or second equation performs about as well as any. However, the restricted estimates provide plausible functions that may be of somewhat greater value in forecasting future prices. Implicit in all of these equations is the assumption that past associations among competing vegetables may continue in the future.

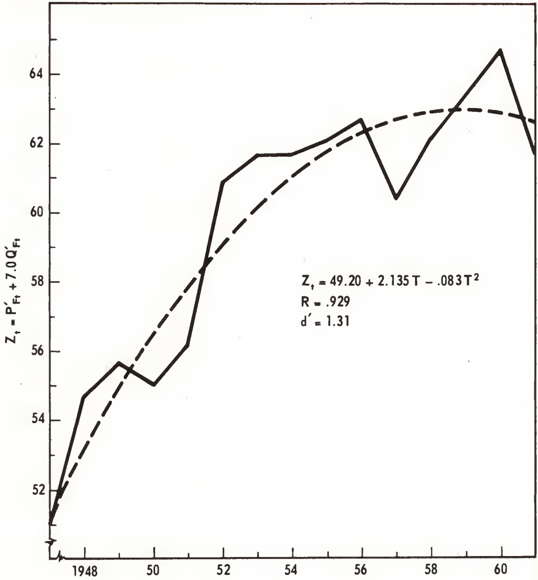

Figure 8. Relation of Deflated Average Price of Frozen Vegetables, Adjusted for Supply and Income Changes, to Time, 1947-1961.

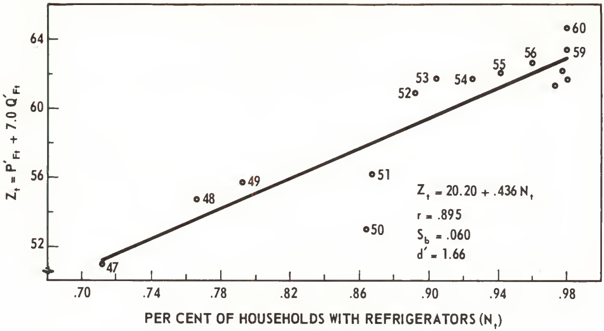

Figure 9. Relation of Deflated Average Price of Frozen Vegetables Adjusted for Supply and Income Changes to Per cent of Households with Refrigerators, 1947-1961.

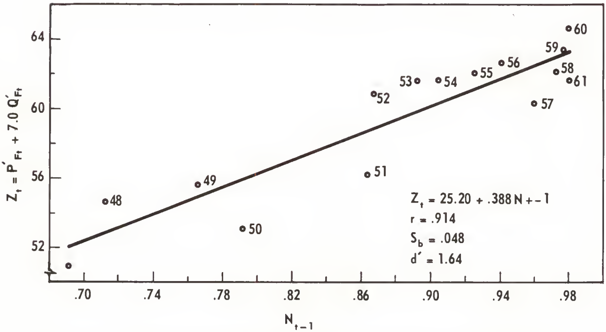

Figure 10. Relation of Deflated Average Price of Frozen Vegetables Adjusted for Supply and Income Changes to Per cent of Households with Refrigerators, Lagged One Year 1947-1961.

TABLE 16

Summary of Regression Estimates of Demand Relationships for Frozen Vegetables, 1947-1961[a/]

	Dependent variable	b_o	Q_{Ft}	Log I_t	T	T^2	N_t	N_{t-1}	r[b/]	R[b/]	d'[c/]	Price flexibility at 1959-61 mean values[d/]
(1)	P_{Ft}	26.85	- .993 (.174)						.846		1.50	- .29
(2)	P'_{Ft}	35.40	-2.382 (.232)						.944		1.57	- .69
(3)[e/]	P'_{Ft}	39.93	-3.106 (.331)	29.88					.934		1.51	- .89
(4)[f/]	P'_{Ft}	49.20	-7.000	67.34	2.135	-.083			.929	.891	1.31	-2.07
(5)[f/]	P'_{Ft}	20.20	-7.000	67.34			.436 (.060)		.895	.840	1.66	-2.07
(6)[f/]	P'_{Ft}	25.20	-7.000	67.34				.388 (.048)	.914	.868	1.64	-2.03

a/ P_{Ft} = actual average price (cents per pound), P'_{Ft} = deflated average price, Q_{Ft} = per capita consumption of frozen vegetables (pounds), I = index of per capita income in 1959 dollars, 1959 = 1.0, N = percent of households having refrigerators. Figures in parentheses are standard errors of regression coefficients.

b/ r is the correlation between fitted variables; R is the correlation between price and all explanatory variables.

c/ Durbin-Watson statistics.

d/ $Q_F = 6.08$, $I = 1.006$, $T = 13$ (max. value), $N = 98$.

e/ Regression fitted to $P'_{Ft} = b_o + b_1(Q_{Ft} - 9.62 \log I_t)$.

f/ Regression fitted to $P'_{Ft} + 7.0\, Q_{Ft} = Z_t = f(T)$ or $f(N)$.

Demand for Individual Vegetables

The common behavior attributes of the various vegetables made it reasonable and expendient to treat them as a single commodity in the previous analysis. However, this procedure leaves us somewhat short of our objectives. Ultimately, we are interested in predicting prices of individual vegetables, which vary around the average (Table 7 and Appendix Table A5).

There is no completely satisfactory method of utilizing information given by the aggregate function to predict individual vegetable prices. A very simple approach is to use average ratios or differences between prices of individual vegetables and the all-commodity average. From these we obtain first approximations of each price,

$$(8)\quad \tilde{P}^{i}_{Ft} = k_i \, P_{Ft}$$

or

$$(9)\quad \tilde{P}^{i}_{Ft} = h_i + P_{Ft}$$

where k_i is an average ratio and h_i is an average difference. Since the proportion that each vegetable is of total consumption may vary, the weighted average of these first approximation prices, $\tilde{P}_{Ft}$, may not equal P_{Ft}. To force the two averages into equality each price computed by equation 8 may be multiplied by $\frac{P_{Ft}}{\tilde{P}_{Ft}} = K_t$, or the weighted average of the h_i, H_t, may be subtracted from prices computed by equation 9. Thus the final adjusted estimates are of the form

$$(10)\quad \hat{P}^{i}_{Ft} = k_i \, K_t \, P_{Ft}$$

or

$$(11)\quad \hat{P}^{i}_{Ft} = h_i - H_t + P_{Ft}.$$

Tables 17 and 18 show how individual prices have varied relative to their average. The ratios and differences for each vegetable typically have been consistently on one side or the other of the average. However, the values for some vegetables show some evidence of trend and averages of ratios or differences for a recent period would seem preferable for forecasting purposes.1/

The fact that price ratios and differences for some commodities have fluctuated suggested that they might be related to changes in relative shares of consumption. A plot of these values in scatter diagrams failed to reveal any significant relationship. The factors causing shifts in relative prices and shares of consumption apparently involve a complex of changes in tastes and supplies that cannot be represented by simple relationships. As noted previously, more complex formulations involve multicollinearity and other statistical problems that appear to defy solution.

Two other procedures were considered, neither of which proved very satisfactory. In the first, the relation between price of an individual vegetable and the average price was estimated by linear regression. Generally high correlations were obtained by this procedure, as would be expected, but in most cases there was a strong indication of serial correlation in the residuals. Therefore, the results are not reported.

The second alternative involved the estimation of individual prices assuming that each vegetable receives some constant average share of total expenditure. The price of a particular vegetable would be estimated by multiplying the previously determined total expenditure for all vegetables by the appropriate proportion and dividing by the quantity of the vegetable. The weighted average of these price estimates would always equal the previously estimated average price. As shown in Table 19, the expenditure shares for some commodities have varied substantially over time. In most cases they appear to be closely related to proportionate shares of consumption. Under the latter circumstances the procedure becomes equivalent to using constant price ratios, as before.

Although the use of constant price ratios is certainly not an ideal basis for forecasting, the general stability of these ratios during recent periods

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1/ Recall that the average price is a deflated value in all except the first regression fitted. To convert to current dollars it is necessary to multiply the estimate of deflated price by the BLS Consumer Price Index adjusted to 1959 = 1.0. The price differences in Table 18 are in terms of current (undeflated) values. The ratios in Table 17 apply to either deflated or undeflated values.

TABLE 17

Ratios of Annual Prices of Individual Vegetables to Arithmetic Means of All Vegetable Prices, 1947-1961

Year	Asparagus	Brussels sprouts	Snap beans	Lima beans	Broccoli	Cauli-flower	Cut corn	Peas	Spinach
1947	1.36	1.29	.93	1.28	1.00	1.04	.83	.85	.64
1948	1.51	1.32	1.01	1.24	1.05	1.08	.85	.91	.66
1949	1.67	1.30	1.03	1.19	1.09	1.08	.86	.84	.64
1950	1.95	1.38	1.05	1.10	1.08	1.09	.97	.89	.64
1951	1.97	1.32	1.10	1.10	1.11	1.15	.96	.88	.65
1952	1.92	1.11	1.05	1.11	1.11	1.10	.95	.88	.66
1953	1.88	1.22	1.08	1.21	1.08	1.04	.99	.82	.60
1954	1.98	1.27	1.11	1.24	1.03	1.00	.90	.83	.63
1955	2.20	1.09	1.03	1.13	1.06	1.14	.81	.95	.64
1956	2.11	1.17	.99	1.06	1.09	1.15	.93	.96	.60
1957	2.19	1.24	1.09	1.18	1.09	1.10	.92	.85	.62
1958	1.99	1.21	1.13	1.15	1.09	1.09	.89	.86	.69
1959	1.95	1.33	1.06	1.09	.98	1.03	1.06	.89	.64
1960	2.02	1.31	1.03	1.10	.99	.98	1.00	.93	.57
1961	2.22	1.39	1.02	1.09	.96	1.00	.93	.95	.57
Average ratios									
1952-61	2.05	1.23	1.06	1.14	1.05	1.06	.94	.89	.62
1959-61	2.06	1.34	1.04	1.09	.98	1.00	1.00	.92	.59

Source: Computed from Table 7.

TABLE 18

Differences between Annual Prices of Individual Vegetables and Arithmetic Means of All Vegetable Prices, 1947-1961

Year	Asparagus	Brussels sprouts	Snap beans	Lima beans	Broccoli	Cauli-flower	Cut corn	Peas	Spinach
1947	8.6	7.0	-1.7	6.6	- .1	1.0	-4.0	-3.6	-8.6
1948	12.5	7.8	.3	5.9	1.2	2.0	-3.7	-2.2	-8.3
1949	16.4	7.5	.7	4.6	2.3	1.9	-3.5	-3.9	-8.9
1950	21.5	8.7	1.2	2.2	1.8	2.1	- .6	-2.5	-8.1
1951	22.5	7.3	2.4	2.2	2.6	3.5	-1.0	-1.9	-8.0
1952	21.5	2.5	1.3	2.6	2.5	2.3	-1.2	-2.9	-7.9
1953	20.8	5.2	1.9	5.0	1.9	.9	- .3	-4.2	-9.4
1954	21.6	5.9	2.4	5.4	.6	.1	-2.1	-3.7	-8.1
1955	26.1	1.9	.5	2.7	1.4	3.0	-4.2	-1.1	-7.8
1956	23.8	3.5	- .2	1.2	1.8	3.1	-1.5	-1.0	-8.6
1957	23.2	4.7	1.7	3.5	1.7	1.9	-1.6	-2.9	-7.4
1958	19.7	4.3	2.7	3.1	1.8	1.8	-2.3	-2.8	-6.1
1959	19.8	6.9	1.3	1.9	- .5	.6	1.2	-2.3	-7.5
1960	22.3	6.7	.6	2.2	- .3	- .4	- .1	-1.5	-9.4
1961	25.4	8.3	.5	2.1	- .8	.1	-1.4	-1.1	-9.0
Average differences									
1952-61	22.4	5.0	1.3	3.0	1.0	1.3	-1.4	-2.4	-8.1
1959-61	22.5	7.3	.8	2.1	- .5	.1	- .1	-1.6	-8.6

Source: Computed from Table 7.

TABLE 19

Relative Shares of Total Frozen Vegetable Expenditures, 1947-1961

Year	Asparagus	Brussels sprouts	Snap beans	Lima beans	Broccoli	Cauliflower	Corn	Peas	Spinach	Other[a/]
	percent of total expenditure									
1947	6.4	2.2	10.3	20.7	4.7	1.8	8.9	29.5	6.1	9.4
1948	7.7	3.3	10.6	17.1	6.4	3.5	7.1	30.0	7.4	6.9
1949	7.8	5.6	10.4	21.0	8.3	3.9	6.8	22.8	6.7	6.7
1950	7.7	4.1	12.2	18.5	7.9	3.3	6.8	25.4	8.1	6.0
1951	6.8	4.5	13.2	16.0	9.2	4.0	7.9	23.8	8.7	5.9
1952	6.4	3.4	12.4	17.5	10.8	4.4	8.2	22.6	7.4	6.9
1953	6.4	4.7	13.1	18.8	9.9	3.5	9.4	21.8	6.5	5.9
1954	6.8	4.1	14.3	16.6	9.7	3.4	7.8	23.5	6.5	7.3
1955	6.7	3.5	12.9	15.5	11.0	4.1	7.9	24.3	7.0	7.1
1956	6.5	4.2	12.9	14.3	10.6	3.9	11.1	25.8	6.0	4.7
1957	6.2	4.2	14.1	15.3	9.7	2.9	9.7	24.0	5.9	8.0
1958	5.1	3.5	15.3	14.2	10.4	3.2	10.6	24.1	6.5	7.1
1959	6.1	4.4	14.0	12.4	9.5	3.4	11.8	23.5	6.5	8.4
1960	6.8	4.2	12.6	12.9	10.0	3.0	10.3	26.4	5.0	8.8
1961	7.4	4.4	11.6	12.5	9.5	3.4	10.9	26.0	5.4	8.9
Average shares										
1952-61	6.4	4.1	13.3	15.0	10.1	3.5	9.8	24.2	6.3	7.3
1959-61	6.8	4.3	12.7	12.6	9.7	3.3	11.0	25.3	5.6	8.7

a/ Includes mixed peas and carrots.

Source: Computed from prices and quantities in Appendix Tables A5 and A3.

suggests that the procedure may have some validity and usefulness in predicting prices of individual vegetables. The estimates may be viewed as general guides, to be modified by careful appraisal of conditions incident to the particular period and marketing situation.

SUMMARY

Per capita consumption of nearly all frozen vegetables has been increasing rapidly and steadily since the development of the industry in the late 1930s. Increases in processed consumption have been largely at the expense of fresh vegetables, with total vegetable consumption showing only a slight upward trend since 1947. Peas are by far the leading frozen vegetable, followed by snap beans, Lima beans, corn, broccoli, spinach, carrots, Brussels sprouts, asparagus and cauliflower, in approximately that order. Recently, there has been an increasing proportion of the total pack in the institutional sizes (over one pound).

The available data on regional per capita consumption suggests that the level of consumption, and presumably the level of demand, is substantially higher in the northern and western states than in the more southerly regions.

Prices of most frozen vegetables have declined gradually since the late 1940s. Margins between farm and retail prices for frozen vegetables have varied from about 57 cents per pound for asparagus to 26 cents per pound for spinach. The processing plant to retail margins have varied from 35 cents for asparagus to about 14 cents for peas. Expressed in percentage terms, farm prices for individual frozen vegetables vary from 12 to 26 percent of the retail price; f.o.b. processing plant prices from 43 to 58 percent of retail.

Cross-section data from three sources were analyzed to obtain estimates of the relation of per capita consumption of frozen vegetables to income. Estimates of income-expenditure elasticity based on a 1951 Bureau of Labor Statistics survey averaged about 1.0 for observations by income groups and roughly 1.8 for geographic groupings. An elasticity of 1.8, for example, would mean that a 1.0 percent increase in per capita income would be associated with a 1.8 percent increase in per capita expenditure. A similar study of regional dollar sales data for all frozen fruits and vegetables compiled by <u>Quick Frozen Foods</u> gave income-expenditure elasticities in the neighborhood of 1.5. Estimates of income-consumption elasticities based on the 1955 USDA Household Food Consumption Survey were much lower, averaging about .6.

Much of the difference in income-expenditure and income-consumption elasticities seems likely to be due to correlations of prices with income and consumption, as would be the case if higher income families purchased better grades and qualities of products. This correlation appears to be accentuated in the geographic cross-section data. It is also possible that certain unmeasured taste

or habit factors vary regionally and with income, but with the effects attributed only to income in this analysis. Geographic cross-section data therefore may tend to produce rather biased estimates of income-expenditure relationships, and especially income-quantity relationships. Evaluated in relation to this problem and the statistical significance of results, the estimates based on the 1955 USDA study seem the most satifactory, particularly for use in further constrained time series analysis.

Time series estimates of demand relationships are developed at the f.o.b. processing plant level and, initially, for all frozen vegetables combined. An analysis in terms of retail values was not possible because of data limitations. Aggregation of all frozen vegetables and treatment as a single commodity was necessary because of very high correlations among frozen vegetables in levels of consumption. This treatment seems reasonable in view of the common behavior attributes causing the multicollinearity, but leaves the results expressed in grosser terms than we would like. A procedure is suggested for utilizing the aggregate relationships to predict price changes for individual vegetables.

As a consequence of further multicollinearity among consumption of frozen and competing fresh and canned vegetables, income, and gradually changing tastes, the analysis proceeds by first examining the relation between prices and consumption of frozen vegetables, neglecting the influence of other variables that might affect frozen vegetable prices. Constraints and modifications are then introduced which cast additional light on the nature of the demand relationship and narrow the range within which structural parameters may be expected to lie. A principal constraint is the use of an income-consumption coefficient based on the cross-section analysis.

Because of the intercorrelation problem it was not possible to determine the separate influence of changes in per capita frozen vegetable supplies on frozen vegetable prices, with competing products held constant. There is, however, some indication of a continuation of past associations among these competing vegetables and, if so, the equations developed may provide a reasonable basis for price forecasting. A final estimate of the demand relationship suggests that at recent levels of consumption the price flexibility for frozen vegetables is in the neighborhood of -2.0. This means that a one percent change in per capita supplies of frozen vegetables is associated, on the average, with a two percent change in the average price in the opposite direction, with the

adjustment in consumption of competing products continuing as in the past. This estimate and the others developed in this analysis should be regarded as general indicators rather than precise relationships. Coupled with a careful appraisal of conditions incident to each market situation they may provide some useful aids in sales and production planning and in the development of further models of interregional competition and growth in the frozen vegetable industry.

APPENDIX

TABLE A1

Commercially Produced Vegetables: Civilian Per Capita Consumption, 1937-61

Year	Fresh equivalent					As percentage of annual total			
	Total fresh and processed	Fresh a/	Processed b/			Fresh	Processed		
			Total	Canned	Frozen		Total	Canned	Frozen
	pounds					percent			
1937	164.3	111.0	53.3	52.3	1.0	67.6	32.4	31.8	0.6
1938	170.1	114.5	55.6	54.6	1.0	67.3	32.7	32.1	.6
1939	174.6	116.6	58.0	56.8	1.2	66.8	33.2	32.5	.7
1940	179.9	116.9	63.0	61.6	1.4	65.0	35.0	34.2	.8
1941	180.8	113.8	67.0	65.4	1.6	62.9	37.1	36.2	.9
1942	193.4	119.0	74.4	71.8	2.6	61.5	38.5	37.2	1.3
1943	186.9	116.7	70.2	68.5	1.7	62.4	37.6	36.7	.9
1944	195.6	123.9	71.7	67.9	3.8	63.3	36.7	34.8	1.9
1945	222.1	134.3	87.8	83.4	4.4	60.5	39.5	37.5	2.0
1946	223.8	129.9	93.9	89.2	4.7	58.0	42.0	39.9	2.1
1947	206.0	122.4	83.6	77.5	6.1	59.4	40.6	37.6	3.0
1948	199.5	123.0	76.5	69.5	7.0	61.7	38.3	34.8	3.5
1949	193.6	116.2	77.4	70.6	6.8	60.0	40.0	36.5	3.5
1950	199.2	115.2	84.0	76.6	7.4	57.8	42.2	38.5	3.7
1951	200.8	111.9	88.9	79.6	9.3	55.7	44.3	39.7	4.6
1952	199.7	111.6	88.1	76.8	11.3	55.9	44.1	38.4	5.7
1953	200.2	109.1	91.1	79.4	11.7	54.5	45.5	39.7	5.8
1954	196.2	107.2	89.0	76.8	12.2	54.6	45.4	39.2	6.2
1955	198.7	105.1	93.6	80.5	13.1	52.9	47.1	40.5	6.6
1956	202.4	107.1	95.3	81.5	13.8	52.9	47.1	40.3	6.8
1957	202.0	106.4	95.6	81.4	14.2	52.7	47.3	40.3	7.0
1958	201.5	103.7	97.8	82.7	15.1	51.5	48.5	41.0	7.5
1959	200.8	102.9	97.9	82.6	15.3	51.2	48.8	41.2	7.6
1960	205.8	106.0	99.8	83.9	15.9	51.5	48.5	40.8	7.7
1961 c/	204.1	104.3	99.8	83.8	16.0	51.1	48.9	41.1	7.8

a/ Excluding melons.

b/ Data include pickles and sauerkraut in bulk; exclude canned and frozen potatoes, canned sweet potatoes, canned baby foods and canned soups.

c/ Preliminary.

Source: U. S. Economic Research Service, The Vegetable Situation, TVS-146, October, 1962.

TABLE A2

Civilian Per Capita Consumption of Principal Commercially Produced Vegetables Utilized for Freezing, United States, Calendar Years, 1937-1961[a/]

Year	Asparagus				Lima Beans[b/]				Snap Beans				Broccoli			Brussels Sprouts			Cauliflower[d/]			Corn[e/]				Peas[f/]				Spinach				Total - nine vegetables			
	Fresh	Canned	Frozen	Total	Fresh	Canned	Frozen	Total	Fresh	Canned	Frozen	Total	Fresh	Frozen	Total	Fresh	Frozen	Total	Fresh	Frozen	Total	Fresh	Canned	Frozen	Total	Fresh	Canned	Frozen	Total	Fresh	Canned	Frozen	Total	Fresh	Canned	Frozen	Total
	fresh equivalent (pounds)																																				
1937	1.2	.70	.06	1.96	.7	.48	.24	1.42	4.0	1.29	.06	5.35	.7	.02	.72	.2	c/	.20	1.7	c/	1.70	5.1	9.85	.13	15.08	2.3	7.76	.41	10.47	2.6	.88	.03	3.51	18.5	20.96	.95	40.41
1938	1.1	.61	.11	1.82	.8	.48	.20	1.48	4.8	1.50	.06	6.36	.7	.02	.72	.2	c/	.20	1.6	c/	1.60	5.2	10.21	.09	15.50	2.1	8.18	.42	10.70	2.5	.81	.04	3.35	19.0	21.79	.94	41.73
1939	1.3	.77	.06	2.13	.9	.55	.25	1.70	5.0	1.55	.05	6.60	.8	.02	.82	.3	c/	.30	1.8	c/	1.80	5.1	10.85	.16	16.11	2.3	8.39	.62	11.31	2.9	.81	.02	3.73	20.4	22.92	1.18	44.50
1940	1.5	.82	.10	2.42	.8	.72	.30	1.82	5.0	1.70	.05	6.75	.6	.01	.61	.3	.02	.32	1.9	.02	1.92	5.6	11.31	.20	17.11	2.1	9.26	.58	11.94	2.7	.98	.07	3.75	20.5	24.79	1.35	46.64
1941	1.5	.82	.11	2.43	.8	.78	.24	1.82	4.6	1.68	.09	6.37	.7	.04	.74	.2	.02	.22	1.4	c/	1.40	6.2	12.05	.17	18.42	2.1	10.38	.89	13.37	2.6	.81	.02	3.43	20.1	26.52	1.58	48.20
1942	1.3	.92	.08	2.30	.7	.80	.54	2.04	4.9	1.93	.13	6.96	.6	.05	.65	.2	.04	.24	1.5	.02	1.52	6.8	14.09	.28	21.17	1.7	10.73	1.16	13.59	2.5	1.14	.23	3.87	20.2	29.61	2.53	52.34
1943	1.2	.83	.12	2.15	.6	.60	.32	1.52	5.3	1.94	.07	7.31	.7	.04	.74	.2	.04	.24	1.4	c/	1.40	6.3	13.57	.10	19.97	1.6	9.86	.75	12.21	2.2	.76	.20	3.16	19.5	27.56	1.64	48.70
1944	1.2	.85	.21	2.26	.6	.33	.38	1.31	4.7	2.12	.20	7.02	1.0	.04	1.04	.2	.09	.29	1.7	.07	1.77	6.7	12.71	.46	19.87	1.7	8.89	1.59	12.18	2.2	1.25	.32	3.77	20.0	26.15	3.36	49.51
1945	1.1	.48	.28	1.86	.6	.47	.37	1.44	4.8	2.44	.25	7.49	.9	.12	1.02	.2	.09	.29	1.9	.07	1.97	7.9	14.13	.54	22.57	1.6	12.06	1.76	15.42	2.3	.99	.48	3.77	21.3	30.57	3.96	55.83
1946	1.1	1.31	.25	2.66	.7	.49	.60	1.79	4.7	2.39	.25	7.34	1.0	.17	1.17	.2	.13	.33	2.0	.13	2.13	7.7	15.83	.63	24.16	1.4	12.82	1.69	15.91	2.0	1.45	.36	3.81	20.8	34.29	4.21	59.30
1947	1.1	.77	.23	2.10	.6	.48	.83	1.91	4.0	2.01	.33	6.34	1.0	.16	1.16	.3	.07	.37	1.8	.07	1.87	7.7	14.80	1.03	23.53	1.1	9.84	2.29	13.23	1.9	1.01	.40	3.31	19.5	28.91	5.41	53.82
1948	.9	.94	.29	2.13	.6	.53	.84	1.97	4.1	2.09	.37	6.56	.9	.23	1.13	.2	.13	.33	1.9	.16	2.06	8.7	12.60	.97	22.27	.9	9.78	2.55	13.23	1.7	.91	.56	3.17	19.9	26.85	6.10	52.85
1949	.9	.86	.25	2.01	.6	.52	1.09	2.21	4.1	2.16	.36	6.62	.9	.29	1.19	.1	.22	.32	1.7	.18	1.88	7.6	12.36	.94	20.90	.8	8.96	2.10	11.86	2.0	1.00	.52	3.52	18.7	25.86	5.95	50.51
1950	.9	.88	.25	2.03	.5	.83	1.14	2.47	3.9	2.49	.45	6.84	1.0	.29	1.29	.1	.16	.26	1.6	.16	1.76	7.7	13.20	.88	21.78	.7	9.16	2.43	12.29	1.7	.84	.68	3.22	18.1	27.40	6.44	51.94
1951	.8	.94	.26	2.00	.5	.70	1.22	2.42	3.8	2.36	.57	6.73	.7	.41	1.11	.2	.24	.44	1.5	.24	1.74	7.6	12.37	1.28	21.25	.5	9.00	2.85	12.35	1.6	1.08	.91	3.59	17.2	26.45	7.98	51.63
1952	.8	.88	.30	1.98	.4	.66	1.59	2.65	3.4	2.51	.67	6.58	.8	.58	1.38	.1	.25	.35	1.4	.33	1.73	7.8	12.27	1.63	21.70	.5	8.63	3.25	12.38	1.5	.93	.90	3.33	16.7	25.88	9.50	52.08
1953	.8	1.03	.32	2.15	.4	.66	1.62	2.68	3.5	2.58	.72	6.80	.7	.58	1.28	.1	.33	.43	1.3	.29	1.59	7.8	13.12	1.86	22.78	.4	8.33	3.52	12.25	1.4	.92	.94	3.26	16.4	26.64	10.18	53.22
1954	.7	.99	.33	2.02	.4	.70	1.47	2.57	3.3	2.67	.81	6.78	.6	.63	1.23	.1	.29	.39	1.3	.31	1.61	8.5	13.22	1.79	23.51	.4	8.26	3.92	12.58	1.1	.68	.94	2.72	16.4	26.52	10.49	53.41
1955	.7	.88	.31	1.89	.3	.72	1.59	2.61	3.3	2.93	.84	7.07	.5	.72	1.22	.1	.31	.41	1.4	.35	1.75	8.2	13.48	2.13	23.81	.4	8.07	3.78	12.25	1.0	.83	1.04	2.87	15.9	26.91	11.07	53.88
1956	.8	1.00	.33	2.13	.3	.74	1.66	2.70	2.8	3.02	.91	6.73	.5	.72	1.22	.1	.36	.46	1.5	.35	1.85	7.9	13.49	2.76	24.15	.3	8.17	4.21	12.68	1.1	.94	1.01	3.05	15.3	27.36	12.31	54.97
1957	.8	1.02	.32	2.14	.3	.71	1.61	2.62	2.9	2.87	.92	6.69	.5	.67	1.17	.1	.35	.45	1.5	.28	1.78	7.7	13.61	2.48	23.79	.3	8.05	4.45	12.80	1.0	.83	.97	2.80	15.1	27.09	12.05	54.24
1958	.8	1.03	.30	2.13	.3	.64	1.61	2.55	2.6	3.09	.99	6.68	.4	.74	1.14	.1	.31	.41	1.3	.31	1.61	8.4	13.61	2.88	24.89	.3	7.92	4.62	12.84	1.1	.89	1.01	3.00	15.3	27.18	12.77	55.25
1959	.7	1.02	.38	2.10	.3	.62	1.55	2.47	2.5	3.08	1.01	6.59	.4	.79	1.19	.1	.36	.46	1.1	.37	1.47	8.5	12.84	2.83	24.17	.2	8.25	4.52	12.97	1.0	.91	1.13	3.04	14.8	26.72	12.94	54.46
1960	.7	.93	.42	2.05	.4	.61	1.62	2.63	2.6	3.11	.96	6.67	.4	.84	1.24	.1	.36	.46	1.4	.35	1.75	8.1	13.46	2.67	24.23	.2	7.44	4.94	12.58	1.0	.85	1.01	2.86	14.9	26.40	13.17	54.47
1961	.7	1.00	.40	2.10	.3	.60	1.51	2.41	2.5	3.16	.86	6.52	.4	.79	1.19	.1	.35	.45	1.1	.37	1.47	8.0	12.59	2.92	23.51	.2	7.47	4.62	12.29	.8	.78	1.04	2.62	14.1	25.60	12.86	52.56

a/ Data for processed exclude quantities consumed in commercially produced soups, and baby foods and in canned vegetable mixtures such as peas and carrots and succotash.

b/ In pod basis.

c/ Less than 0.005 pound.

d/ Close trim basis.

e/ "On cob" basis.

f/ "In pod" basis.

Source: The Vegetable Situation, U. S. Department of Agriculture, Economic Research Service, TVS-146, October 1962.

TABLE A3

Vegetables, Frozen: Per Capita Consumption 1937-61[a]

Year	Leafy, green, and yellow vegetables											Other vegetables					
	Asparagus	Snap beans	Lima beans	Carrots	Peas	Peas and carrots	Pumpkin and squash	Broccoli	Brussels sprouts	Spinach	Other[b]	Cauliflower	Corn, cut basis	Succotash	Rhubarb	Potato products	Total[c]
	pounds																
1937	0.03	0.05	0.11	d/	0.15	d/	d/	0.01	d/	0.02	d/	d/	0.03	e/	e/	e/	0.40
1938	.05	.05	.09	d/	.15	d/	0.01	.02	d/	.02	d/	d/	.02	e/	e/	e/	.41
1939	.03	.04	.11	d/	.22	0.01	.01	.02	d/	.01	0.01	d/	.04	e/	e/	e/	.50
1940	.05	.04	.13	d/	.21	d/	.01	.01	0.01	.04	.01	0.01	.05	e/	e/	e/	.57
1941	.05	.07	.11	0.01	.32	d/	.01	.03	.01	.01	.01	d/	.04	e/	e/	e/	.67
1942	.04	.10	.24	.01	.41	.01	.02	.03	.02	.13	.01	.01	.07	e/	e/	e/	1.10
1943	.06	.05	.14	d/	.27	.01	.03	.03	.02	.11	d/	d/	.02	e/	d/	e/	.74
1944	.11	.16	.17	.03	.56	.02	.07	.03	.05	.18	.06	.04	.11	d/	0.04	e/	1.63
1945	.14	.20	.17	.02	.62	.02	.08	.08	.05	.26	.04	.04	.13	0.01	.04	e/	1.90
1946	.13	.20	.27	.04	.60	.04	.03	.12	.07	.20	.06	.07	.15	.01	.05	e/	2.04
1947	.11	.26	.38	.07	.81	.04	.06	.11	.04	.22	.09	.04	.25	.01	.08	0.01	2.58
1948	.14	.29	.38	.05	.91	.07	.05	.17	.07	.31	.10	.09	.23	.05	.02	.05	2.98
1949	.13	.28	.49	.10	.75	.04	.03	.21	.12	.29	.11	.10	.22	.05	.02	.07	3.01
1950	.12	.35	.51	.08	.86	.06	.06	.22	.09	.38	.15	.09	.21	.05	.03	.12	3.38
1951	.13	.45	.55	.09	1.02	.08	.06	.31	.13	.50	.22	.13	.31	.06	.04	.23	4.31
1952	.15	.53	.71	.11	1.16	.10	.06	.44	.14	.50	.33	.18	.39	.08	.04	.36	5.28
1953	.16	.57	.73	.13	1.25	.09	.07	.43	.18	.51	.30	.16	.45	.06	.03	.31	5.43
1954	.17	.64	.66	.17	1.40	.11	.09	.47	.16	.51	.36	.17	.43	.07	.05	.44	5.90
1955	.16	.66	.72	.21	1.34	.10	.09	.54	.17	.57	.54	.19	.51	.06	.04	.74	6.64
1956	.17	.72	.75	.15	1.50	.08	.10	.54	.20	.56	.39	.19	.66	.03	.02	1.20	7.26
1957	.16	.73	.73	.27	1.58	.12	.13	.50	.19	.53	.48	.15	.59	.07	.04	1.22	7.49
1958	.15	.79	.72	.24	1.64	.11	.09	.56	.17	.55	.66	.17	.70	.06	.03	1.44	8.08
1959	.19	.80	.69	.31	1.61	.14	.10	.59	.20	.62	.61	.20	.68	.05	.02	2.07	8.88
1960	.21	.76	.73	.35	1.76	.16	.09	.63	.20	.55	.72	.19	.64	.03	.03	2.74	9.79
1961[f]	.20	.68	.68	.33	1.64	.14	.12	.59	.19	.57	.93	.20	.70	.04	.04	2.94	9.99

a/ Civilian consumption only, beginning 1941.

b/ Included with leafy, green, and yellow because most items included are considered to be greens.

c/ Computed from unrounded data.

d/ Less than 0.005 pound.

e/ Included with "other."

f/ Preliminary

Source: The Vegetable Situation, U. S. Department of Agriculture, Economic Research Service, TVS-142, October 1962.

TABLE A4

Retail Prices of Frozen Vegetables in Three Cities, 1957-58 to 1960-61[a]

	Fiscal year				Fiscal year				Fiscal year			
	57-58	58-59	59-60	60-61	57-58	58-59	59-60	60-61	57-58	58-59	59-60	60-61
	cents per pound											
	Asparagus				Broccoli				Brussels sprouts			
Washington D.C.	78.6	76.5	75.2	77.1	42.2	43.7	42.2	42.1	55.7	54.4	53.0	54.9
Minneapolis-St. Paul	78.7	77.9	77.1	76.5	43.5	42.9	42.6	41.9	52.6	50.6	49.4	48.5
Seattle	75.0	76.0	75.0	76.2	41.4	41.3	42.9	43.5	52.5	52.2	53.0	53.8
	Cauliflower				Corn				Baby Lima beans			
Washington D.C.	42.9	43.4	42.6	42.9	32.8	33.4	33.6	36.0	42.1	42.1	42.2	42.2
Minneapolis-St. Paul	44.5	43.0	43.2	43.7	33.4	33.0	34.6	35.2	45.4	44.2	43.4	43.4
Seattle	43.4	43.5	43.2	44.5	31.0	31.8	32.5	34.7	44.6	43.5	44.2	45.9
	Fordhook Lima beans				Snap beans				Peas			
Washington D.C.	42.1	42.1	41.9	42.6	39.8	41.2	40.9	40.9	30.7	32.0	32.0	33.3
Minneapolis-St. Paul	47.4	45.6	44.5	44.5	41.1	41.6	40.9	40.7	30.9	31.4	32.0	33.4
Seattle	43.7	44.2	44.3	45.9	38.8	40.0	39.6	40.5	30.2	30.7	30.4	32.5
	Leaf spinach											
Washington D.C.	28.7	29.3	30.7	29.3								
Minneapolis-St. Paul	31.1	32.8	32.1	29.9								
Seattle	27.7	29.7	30.7	28.7								

a/ Prices are quoted for grade A quality in the principal retail size, mainly the 10-ounce package. They are based on quarterly observations in retail food stores.

Source: Computed from data collected for the U. S. Department of Agriculture by the Bureau of Labor Statistics, U. S. Department of Labor.

TABLE A5

Data Used in Time Series Analyses of Demand Relationships for Frozen Vegetables

Year	F.O.B. plant prices, deflated by Consumer Price Index a/										Total per capita consumption c/		Index of per capita income		BLS Consumer Price Index, all commodities	United States homes with	
	Asparagus	Brussels sprouts	Snap beans	Lima beans	Broccoli	Cauliflower	Corn	Peas	Spinach	Average b/	Actual	Adjusted d/	Current dollars	1959 e/ dollars		refrigerators	freezers
	cents per pound										pounds		1959=100			percent	
1947	37.8	36.0	25.9	35.5	27.7	29.0	23.2	23.7	17.9	27.8	2.34	3.31	61.9	79.3	86.2	71.2	NA
1948	44.6	38.9	29.8	36.6	30.9	31.9	25.0	26.8	19.4	29.5	2.76	3.59	67.7	81.9	82.5	76.6	4.3
1949	50.3	39.4	31.1	35.9	33.0	32.6	25.9	25.5	19.3	30.2	2.78	3.63	66.7	81.5	81.7	79.2	5.2
1950	53.7	38.2	29.1	30.3	29.8	30.2	26.9	24.6	17.8	27.6	3.02	3.63	71.8	86.4	82.5	86.4	7.2
1951	51.1	34.1	28.6	28.4	28.8	29.9	24.8	22.7	16.9	25.9	3.76	4.33	77.2	87.3	89.1	86.7	9.3
1952	49.3	28.4	27.1	28.5	28.4	28.2	24.4	22.5	17.0	25.7	4.49	5.02	79.7	88.1	91.1	89.2	11.5
1953	48.5	31.5	27.9	31.3	27.9	26.8	25.5	21.2	15.6	25.8	4.72	5.12	83.0	90.8	91.8	90.4	13.4
1954	47.2	30.2	26.4	29.6	24.4	23.9	21.5	19.8	15.0	23.8	4.96	5.40	83.0	89.9	92.1	92.5	15.1
1955	52.0	25.7	24.2	26.6	25.1	26.9	19.0	22.4	15.1	23.6	5.23	5.49	87.1	94.0	91.9	94.1	16.8
1956	48.4	26.7	22.7	24.2	24.9	26.3	21.3	21.9	13.7	22.9	5.55	5.68	91.4	96.9	93.3	96.0	18.0
1957	44.4	25.2	22.1	23.9	22.1	22.3	18.7	17.3	12.6	20.3	5.62	5.72	94.6	97.6	96.5	97.3	19.2
1958	40.1	24.5	22.9	23.3	22.0	22.0	17.9	17.4	14.0	20.2	5.86	5.99	95.8	96.9	99.1	97.7	21.0
1959	40.6	27.7	22.1	22.7	20.3	21.4	22.0	18.5	13.3	20.8	6.08	6.08	100.0	100.0	100.0	98.0	22.1
1960	43.3	28.0	22.0	23.5	21.1	21.0	21.3	19.9	12.1	21.4	6.21	6.18	102.1	100.7	101.5	98.0	23.4
1961	45.0	28.3	20.7	22.3	19.5	20.4	18.9	19.2	11.5	20.3	5.96	5.91	103.9	101.2	102.7	98.0 f/	NA

a/ 1959 = 100. Actual f.o.b. prices are given in Table 7.

b/ Weighted by per capita consumption.

c/ Excludes potatoes, pumpkin and squash, rhubarb and other minor vegetables.

d/ Computed by subtracting log of per capita income, multiplied by the conditional income coefficient (9.62), from per capita consumption.

e/ Deflated by implicit price deflator for GNP, as developed in the Supplements to Economic Indicators.

f/ Preliminary estimate.

Source: Prices computed from monthly quotations in Quick Frozen Foods. Per capita consumption from data in Table A3. Per capita income data and Consumer Price Index from 1960 and 1962 Supplements to Economic Indicators, U. S. Congress Joint Economic Committee, Government Printing Office, Washington D.C. Refrigerator and freezer data from Economic Almanac, National Industrial Conference Board, 1962.

TABLE A6

Average Farm Prices of Vegetables for Fresh Markets, Principal Commodities Utilized for Freezing, 1947-1962

Year	Asparagus	Snap beans	Lima beans	Carrots	Peas	Broccoli a/	Cauliflower a/ b/	Corn	Brussels sprouts a/	Spinach	Simple average all vegetables	Weighted averages: Broccoli, cauliflower and Brussels sprouts	Weighted averages: Snap beans, Lima beans, corn and peas	Weighted averages: All vegetables c/	Weighted averages: All vegetables excluding carrots
	cents per pound														
1947	12.35	7.19	7.91	3.30	7.20	9.17	7.08	2.78 d/	e/	4.55	6.84	7.07 f/	4.69	4.86	5.49
1948	11.56	8.13	8.66	3.42	7.29	9.38	6.39	4.00	e/	4.65	7.05	6.86 f/	5.59	5.19	5.97
1949	12.15	7.34	7.99	2.80	7.09	9.04	5.58	2.99	10.94	4.97	7.09	6.93	4.83	4.66	5.50
1950	12.90	7.53	6.87	2.48	7.20	8.36	5.69	3.28	10.06	5.57	6.99	6.84	4.93	4.63	5.67
1951	14.13	8.13	8.00	3.61	7.39	9.38	6.58	3.49	9.87	5.44	7.60	7.67	5.25	5.25	6.02
1952	13.47	9.23	9.18	3.06	6.77	8.57	6.62	3.72	10.64	6.01	7.73	7.47	5.57	5.23	6.25
1953	12.89	9.08	8.77	3.22	8.28	7.82	5.67	3.97	10.01	5.47	7.52	6.60	5.75	5.23	6.18
1954	13.50	8.17	8.64	3.30	8.17	7.82	6.47	3.63	6.93	5.73	7.24	6.90	5.12	4.96	5.74
1955	14.90	7.92	7.15	3.21	8.11	7.91	6.75	3.20	7.82	6.18	7.32	7.20	4.73	4.81	5.57
1956	14.20	9.16	8.77	2.62	8.89	7.79	6.03	3.86	7.81	5.93	7.51	6.53	5.44	4.91	6.08
1957	13.00	9.20	9.03	3.17	9.35	7.36	6.08	4.32	6.35	6.00	7.39	6.40	5.84	5.28	6.31
1958	12.80	8.05	8.37	2.68	8.08	7.73	6.73	3.43	8.33	6.56	7.28	7.04	4.71	4.62	5.54
1959	13.67	9.10	10.01	2.94	10.17	7.87	6.14	3.66	8.03	6.52	7.81	6.69	5.12	4.87	5.79
1960	13.65	8.59	8.07	2.29	9.30	7.93	6.01	4.00	8.61	6.70	7.52	6.55	5.29	4.76	5.94
1961	15.17	8.66	8.74	2.98	9.56	8.04	6.43	3.96	8.64	6.52	7.87	6.97	5.26	5.05	6.02
1962 g/	15.83	9.14	9.08	2.75	10.38	8.27	7.17	3.86	8.82	7.14	8.24	7.55	5.32	5.10	6.20

a/ Includes both fresh market and processing.

b/ Close trim basis.

c/ Weighted by per capita consumption.

d/ Does not include green field corn. Estimates are incomplete for some states prior to 1949.

e/ Figures not available prior to 1949.

f/ Cauliflower and broccoli only.

g/ Preliminary figures, weighted by 1961 quantities.

Source: U. S. Statistical Reporting Service, Vegetables--Fresh Market, annual issues.